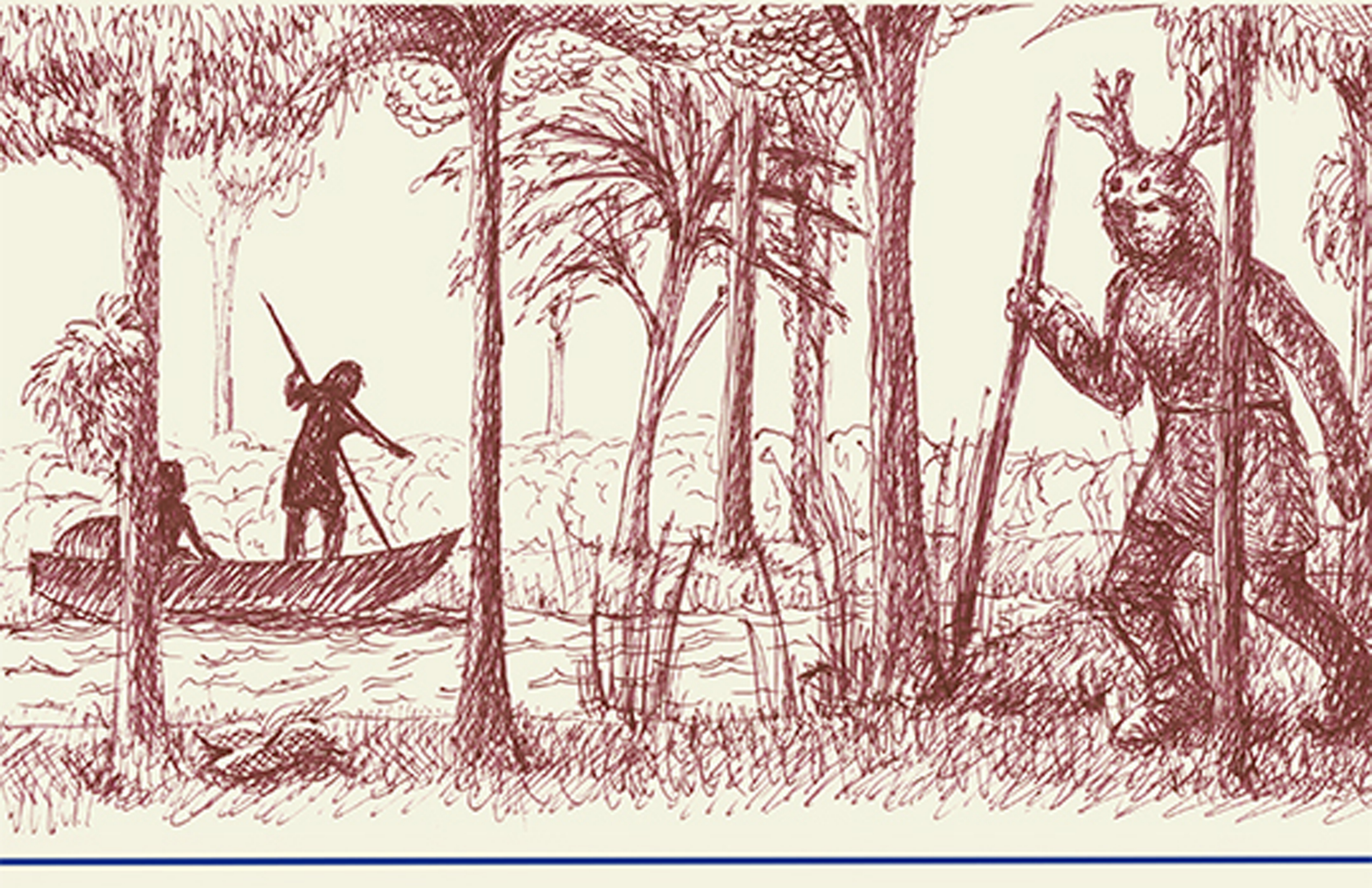
Wild Things

Recent Advances in Palaeolithic and Mesolithic Research



edited by

Frederick W. F. Foulds, Helen C. Drinkall, Angela R. Perri,
David T. G. Clinnick, James W. P. Walker

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Back cover: The entrance to Cathole Cave. © George Nash.

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Preface

In recent years research in the Palaeolithic and Mesolithic has been breaking boundaries worldwide, including pushing back the earliest dates for the human occupation of Britain, the identification of a new species of hominin, cracking the Neanderthal genome and discovering the UK's earliest Mesolithic house. This volume, the culmination of a highly successful conference, aims to celebrate this trend with papers presenting a plethora of new research from a variety of geographical and methodological perspectives.

In March 2012, Durham University played host to the first *Where the Wild Things Are* conference, a symposium designed to provide an international forum that allowed the latest in Palaeolithic and Mesolithic research to be presented and discussed. It attracted over 120 delegates from some eighteen countries and allowed a wide range of researchers within the fields of Palaeolithic and Mesolithic archaeology to present over fifty papers, demonstrating the breadth of new and innovative advances in the analysis and understanding of these periods. The mixture of contributors from a diverse range of backgrounds allowed for a greater degree of interdisciplinary discourse that is not often seen at similar conferences, where the Palaeolithic and Mesolithic are generally split apart.

The papers within this volume bring the ideas and interpretations set forth at the *Wild Things* conference to the wider archaeological audience. Collecting contributions from archaeologists conducting research within the British Isles, France, Portugal, Denmark, Russia, the Levant and Europe as a whole, this volume aims to present a cross-section of the exciting range of research currently being conducted to improve our understanding of the Palaeolithic and Mesolithic. By combining papers that discuss these two periods together, it is hoped that further dialogue between practitioners of Palaeolithic and Mesolithic research can be encouraged.

While this volume is the product of the individual contributors themselves, it would not have been possible if not for the hard work and dedication of a select few individuals. Chief amongst them are my co-editors, who worked tirelessly to coordinate, promote and, ultimately, host such a successful event, especially Helen Drinkall and Angela Perri, who acted as the principal organisers. In addition, they have helped greatly in providing corrections and commentary on the papers that appear here. As a team, we would also like to thank Peter Rowley-Conwy, Mark White, Paul Pettit, and Matt Pope for agreeing to chair themed sessions, and all those who agreed to provide peer-review support.

Finally, *Where The Wild Things Are* continues to thrive, seeing a second conference event in January 2014 that saw a similar number of delegates in attendance and over thirty papers that continued to expound upon the constantly evolving research within Palaeolithic and Mesolithic studies. Hopefully, we shall see these symposia go from strength to strength, allowing for an interdisciplinary sounding board that will help researchers at all levels advance and disseminate their work.

Frederick F. W. Foulds
January 2014

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1. Chronology of the Mid Upper Palaeolithic of European Russia: Problems and prospects

Natasha Reynolds

Abstract

The archaeological record of the Mid Upper Palaeolithic (MUP) of Russia (*c.* 30,000–20,000 ^{14}C years BP) is important both intrinsically and as part of a wider European archaeological landscape. Numerous issues have meant that the archaeology has not received the attention it deserves in the West, and it is not currently possible to easily synthesise information on Russian sites with that from elsewhere in Europe. One of the biggest problems for making sense of the archaeology is that of chronology, as there is no consensus on a chronocultural scheme for this time period in Russia, and both absolute and relative dating of sites remains problematic. The archaeology of the sites of Kostenki 8 Layer 2 and Kostenki 4 are outlined to demonstrate the importance of these sites and to illustrate some of the problems that need to be overcome in order to determine an accurate chronology. There is great potential for future work to improve the understanding of these sites, and hence to illuminate broader archaeological debates related to the European MUP.

Introduction

The Upper Palaeolithic record of Russia, with its rich sites that have yielded huge lithic assemblages, dwelling-structures, mobiliary art, and burials, holds great interest for archaeologists worldwide. Its clear similarities to the contemporary archaeology of the rest of Europe mean that it is always included as part of the European Upper Palaeolithic when this is considered as a whole. However, the archaeology from this region remains relatively under-exposed in the West, and there are huge difficulties in synthesising archaeological evidence from across the continent. This has been bemoaned for many years but more than two decades after the collapse of the USSR, progress remains slow.

Geopolitical realities constituted a serious barrier to communication throughout most of the twentieth century. Although the Iron Curtain has fallen, economic barriers to co-operation remain in place, and colleagues from all parts of Europe often find it difficult to attend conferences at distant parts of the continent. The language barrier still poses major difficulties, and although Russian archaeologists increasingly publish in English and French, the vast majority of primary literature is inaccessible to the non-Russophone. The persistent differences in intellectual traditions are, perhaps, less obvious. Soviet archaeological thought diverged strongly from Western traditions (Bulkin *et al*. 1982; Davis 1983; Vasil'ev 2008); post-Soviet Russian archaeological thought has inherited many of the particularities of the local tradition.

The Russian record is undoubtedly deserving of international publication and discussion. The mobiliary art and claimed existence of dwelling structures are well known worldwide; descriptions of the rest of the archaeology have had less dissemination. In combination with evidence from across Europe, the record offers an opportunity to gain an understanding of pan-European cultural processes during the Mid Upper Palaeolithic (MUP). The present article attempts to give a review of the current state of affairs in the study of this region from a western European standpoint, and to outline two major Russian MUP sites. Locations of sites discussed in the text can be found in Figure 1.1.

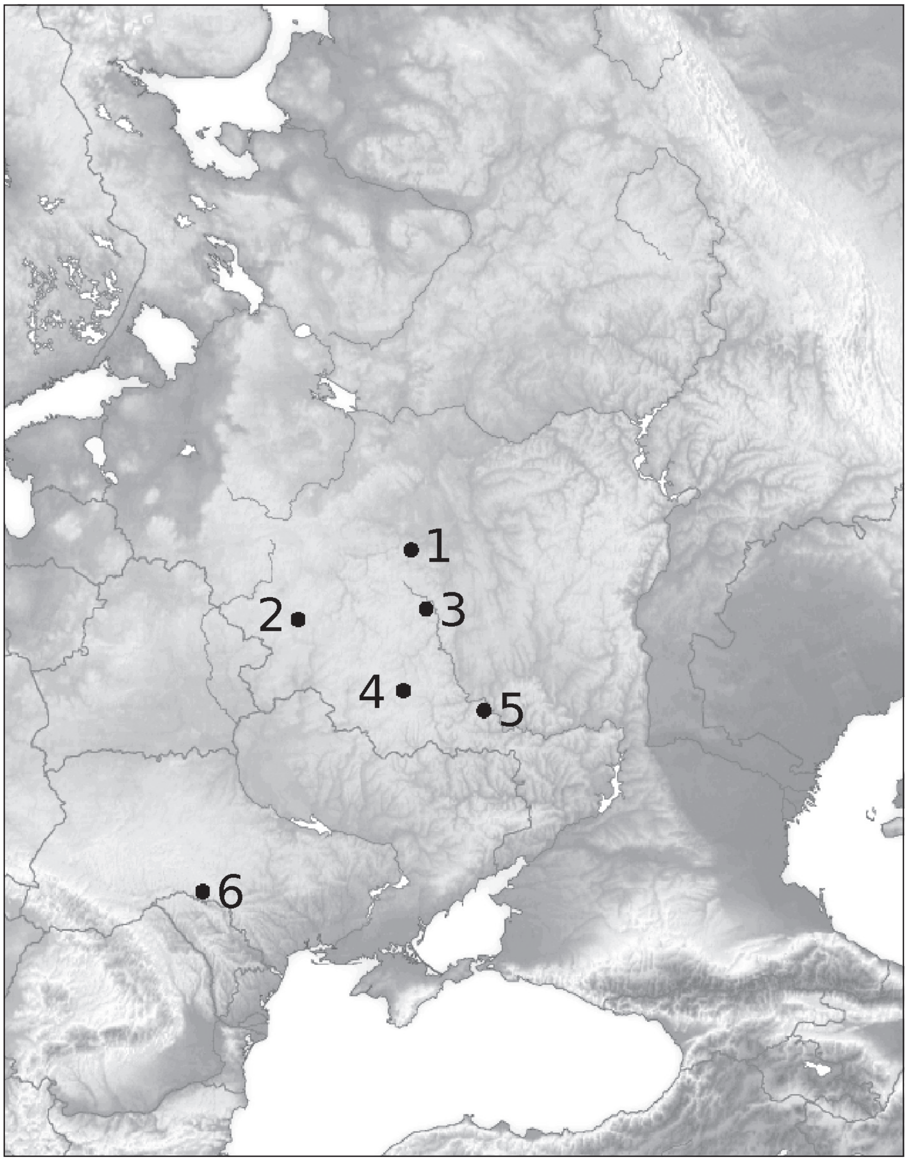

Figure 1.1. Some sites and regions mentioned in the text: 1. Zaraysk; 2. Khotylevo-2; 3. Gagarino; 4. Avdeevo; 5. The Kostenki-Borshchevo area; 6. Molodova-5.

The European MUP

The European MUP, frequently treated as synonymous with the Gravettian, dates from approximately 30,000 to 20,000 ^{14}C years BP. The period has been described as a "Golden Age" (Roebroeks *et al*. 2000) and has provided archaeological evidence for a broad spectrum of human activity, including textile production, ceramic production, processing of plant resources, and, more controversially, dog domestication (*e.g* Aranguren *et al*. 2007; Germonpré *et al*. 2012; Revedin *et al*. 2010; Soffer 2004; Vandiver *et al*. 1989).

The traditional type-fossils of the Gravette point and backed bladelet are found widely and in large numbers throughout this period; however, a great deal of temporal and regional variation is known among Gravettian industries. Industries such as the Maisierian/Fontirobertian, Pavlovian, and Noaillian, which date to this time period, are idiosyncratic and geographically and chronologically restricted, and demonstrate the technological diversity of the European MUP. They are usually (but not always) treated as sub-types within a larger Gravettian cultural and technological entity. The term 'Gravettian' is itself ambiguous, and may be used to describe a technocomplex or group of technocomplexes, a time period, or a perceived cultural grouping – a state of affairs which reflects the historical development of the term, as well as the perhaps under theorised nature of its usage (de la Peña Alonso 2012).

In recent years, great progress has been made in improving our chronology of, and understanding of the variability within, the Gravettian. Excellent work has been carried out on Western European lithic assemblages, often incorporating intra- and inter-site comparison (*e.g*. Borgia 2009; Klaric 2007; Pesesse 2006; Wierer 2013). Technological studies, for example on methods of bladelet production, are proving to be especially productive. Much attention has also been concentrated on the earliest Gravettian and the timing and nature of the Aurignacian/Gravettian boundary, with various claims across Europe for Gravettian assemblages earlier than 30,000 ^{14}C years BP (Conard and Moreau 2004; Haesaerts *et al*. 1996; Prat *et al*. 2011). The relationship between the Aurignacian and the Gravettian, if any, continues to be debated on the basis of evidence from various areas across Europe (Borgia *et al*. 2011; Kozłowski 2008; Moreau 2011; Pesesse 2008, 2010). Recent projects seeking to improve the radiocarbon chronology of the Upper Palaeolithic have dramatically improved our chronological framework for this time period (Higham *et al*. 2011, Jacobi *et al*. 2010).

The MUP archaeology of Russia and the Kostenki-Borschevo region

In contrast with the rest of Europe, the Mid Upper Palaeolithic of Russia is far from synonymous with the Gravettian. Rather, it is widely held that several other industries were also extant during the MUP, sometimes overlapping in time within a very small geographical region. The Gorodtsovian, Gravettian, Kostenki-Avdeevo Culture and Epigravettian are widely described (Sinitsyn 2010); other phenomena such as the "Epi-Aurignacian" (Anikovich 2005a) are also sometimes included in the Russian MUP. The majority of the evidence for the MUP of European Russia derives from the famous Kostenki-Borshchevo region, near the city of Voronezh, where twenty-six Upper Palaeolithic sites have been identified.

The Kostenki-Borshchevo sequence

The sites of the Kostenki-Borshchevo area are found along the right bank of the Don River and within a series of ravines, which open onto the river, along a distance of perhaps seven kilometres. Several river terraces have been identified above the floodplain and extend into the ravines; the Palaeolithic cultural layers were found within deposits on the first and second terraces.

On the second terrace, a series of humic layers, loessic layers, and a visible tephra deposit were found. The sequence from the base consists of a Lower Humic Bed overlain by loessic deposits and a tephra layer. These are in turn covered by an Upper Humic Bed, followed by further loessic deposits and a thinner humic layer known as the Gmelin soil, which is sealed by another series of loessic deposits, believed to date to the Last Glacial Maximum (Holliday *et al*. 2007). Rogachev (1957), working in the 1950s, used this stratigraphy to create a basic tripartite chronological grouping for the sites, which remains in use to this day: 1) Lower Humic Bed sites, 2) Upper Humic Bed sites, 3) sites from above the Upper Humic Bed. On the first terrace, the stratigraphy is more limited, containing only loessic deposits and the Gmelin soil. Therefore, all sites from this terrace are attributed to Rogachev's third chronological group.

Chronostratigraphy and palaeoclimatic correlation

The part of the Kostenki geological sequence relating to the MUP (*i.e*. the Upper Humic Bed and above) has yet to yield precise, accurate and consistent absolute dates. However, the tephra deposit between the Upper and Lower Humic Beds has been securely identified as the Campanian Ignimbrite, dated to approximately 40,000 calendar years ago (Fedele *et al*. 2008; Giaccio *et al*. 2008; Hoffecker *et al*. 2008; Pyle *et al*. 2006; Sinitsyn 2003). At least three individual palaeosols have been identified within the Upper Humic Bed (Sedov *et al*. 2010). By comparison with well-studied sedimentological sections at Kurtak (Russia), Mitoc-Malu Galben (Romania) and Molodova (Ukraine) (Haesaerts *et al*. 2010), it is possible to suggest a tentative correlation between the Upper Humic Bed and Greenland Interstadials 8–5, and between the Gmelin soil and one, or both, of Greenland Interstadials 4 and 3. This correlation, however, is based purely on published descriptions and awaits publication of a systematic study and dating of the chronostratigraphy. Correlations between the Upper Humic Bed and the Bryansk soil (Sedov *et al.* 2010), and the Bryansk soil and Greenland Interstadial 8 (Simakova 2006) have previously been suggested.

Russian MUP industries

The Gravettian of Russia is defined by the presence of Gravette points/microgravettes and backed bladelets, in layers of the expected age (*c*. 30,000–20,000 ^{14}C years BP). The Kostenki-Avdeevo Culture, importantly, is generally treated separately, despite the presence of backed bladelets and Gravette points in sites of that industry (Gavrilov 2008; Lisitsyn 1998; Tarasov 1979). Perhaps six Kostenki sites (Kostenki 8 Layer 2, Kostenki

4 Layers 1 and 2, Kostenki 9, Borshchevo 5, Kostenki 21 Layer 3, Kostenki 11 Layer 2) relate to the Gravettian excluding the Kostenki-Avdeevo Culture (Sinitsyn 2007). Kostenki 8 Layer 2, discussed in detail below, is found in the Upper Humic Bed and has yielded a relatively early radiocarbon date of 27,700 ± 700 ^{14}C BP (GrN-10509); the other sites are all found above the Upper Humic Bed and hence belong to Rogachev's third chronological group. Sinitsyn (2007) argues that the sites other than Kostenki 8 Layer 2 represent four *faciés* of the Recent Gravettian, which co-existed at Kostenki alongside the Kostenki-Avdeevo Culture. All the sites have yielded sizeable numbers of backed bladelets. Radiocarbon dates for sites other than Kostenki 8 Layer 2 range widely; however, Sinitsyn (2007), following earlier work, dates the third chronological group to 27,000 to 20,000 ^{14}C years BP.

The Gorodtsovian industry is unique to Eastern Europe and, perhaps, to the Kostenki region. The type-site for the industry is Kostenki 15 (Gorodtsovskaya), found within the Upper Humic Bed (and hence belonging to Rogachev's second chronological group). Unusually, the type-fossil for this industry is not lithic but osseous: a number of remarkable bone "shovels" were discovered at Kostenki 15 (Rogachev 1957). The lithic assemblage from this site is relatively small, numbering about 350 retouched flint and quartzite pieces among a total collection of more than 2000 lithics. The collection includes large numbers of retouched blades and scrapers made on blade blanks, splintered pieces, and retouched flakes but, notably, no bladelets (Klein 1969; Sinitsyn 2010). There is no clear consensus on which other Kostenki sites should be attributed to the Gorodtsovian; Kostenki 14 Layer 2, Kostenki 12 Layer 1 and Kostenki 16 are often included, but there is substantial variation between researchers (Rogachev and Sinitsyn 1982; Sinitsyn 2010). The site of Talitsky in the Urals is sometimes included, and recently an assemblage from the site of Mira (Ukraine) has been attributed to it (Sinitsyn 2010; Stepanchuk *et al*. 1998). The available radiocarbon dates for Kostenki 15 are as follows: 25,700 ± 250 ^{14}C years BP (GIN-8020) (Chabai 2003); 21,720 ± 570 ^{14}C years BP (LE-1430) (which is inconsistent with the site's stratigraphic position, see Rogachev and Sinitsyn 1982). Some AMS radiocarbon dates for Kostenki 14 Layer 2 range between 29,240 ± 330 (GrA-13312) and 26,700 ± 190 (GrA-10945) ^{14}C years BP (Holliday *et al*. 2007). These ages overlap not only with the Gravettian elsewhere in Europe but also with the Gravettian as represented at Kostenki 8 Layer 2. It has been suggested that the Gorodtsovian sites do not represent a cultural grouping, but, rather, are a reflection of site function including kill-butchery events (Hoffecker 2011).

The Kostenki-Avdeevo Culture is found more widely than the earlier Gravettian, including at Kostenki (Kostenki 1 Layer 1, Kostenki 14 Layer 1, and Kostenki 18), Avdeevo, Zaraysk, and (more problematically) Khotylevo-2 and Gagarino (Sinitsyn 2007). Similarities with sites beyond European Russia are often stressed, as demonstrated by the technocomplex's frequent inclusion in larger units (*e.g*. the Willendorf-Pavlov-Kostenki-Avdeevo cultural unity or the 'shouldered-point horizon' of Eastern Europe (Grigor'ev 1993; Otte and Noiret 2003; Svoboda 2007). The technocomplex is defined according to the presence of shouldered points and Kostenki knives in the lithic assemblage, female ('Venus') figurines, and long lines of hearths, surrounded by pits and oriented north-west to south-east. These latter features are generally interpreted as the remains of domestic structures. The majority of frequently cited dates for these sites fall between 24,000 and 21,000 ^{14}C years BP (Amirkhanov 2009; Anikovich 2005b; Gavrilov 2008; Sinitsyn 2007); at Kostenki, all relevant cultural layers are found above the Upper Humic Bed, *i.e*. in Rogachev's third chronological group. The Epigravettian, not discussed here, is also represented by multiple sites at Kostenki.

Dating of assemblages

The tripartite scheme of Rogachev is certainly useful for a general relative chronology. However, the lengths of time included in each part of the scheme (probably up to ten millennia) means that it is a very low-resolution chronology. Within the second chronological group (found within the Upper Humic Bed), Aurignacian, Gravettian, Gorodtsovian and Streletskayan assemblages are all found; the third chronological group includes Gravettian, Gorodtsovian, Kostenki-Avdeevo Culture and Epigravettian assemblages (Sinitsyn 2007). Some consensus has emerged on the stratigraphical relationships, and hence chronological relationships, between these industries (*e.g*. the Epigravettian is later than the Kostenki-Avdeevo Culture). However, the nature of the sites, with their lack of long sequences, means that further attempts to elaborate the chronology necessitate the use of absolute – usually radiocarbon – dating.

Known problems with radiocarbon dating

It has become increasingly clear in recent years that the radiocarbon dating of periods prior to 20,000 years ago presents methodological hazards which, if not carefully avoided, can result in incorrect dates being obtained, usually younger than the true age of the samples (Higham 2011). The problems are especially caused by the presence of contaminant younger or modern carbon in samples. Thus, the adequate removal of contaminant carbon is essential to achieve reliable dating. Secure provenancing of samples is also vital. Many radiocarbon measurements taken on Palaeolithic bone and other samples over the past few decades were not processed using what we now know to be best practice for dealing with such samples. This means that many published dates must be treated with caution. Criteria have been published for evaluating the reliability of radiocarbon dates (*e.g*. Pettitt *et al*. 2003). However, for most of the dates available for Russian MUP sites, the relevant information is simply not available.

Previous use of dates in building chronology

A substantial number of radiocarbon dates have been obtained for the Kostenki-Borshchevo sites. Unfortunately, for most, if not all, layers where more than one date has been published, the dates are mutually inconsistent. For example, for the Aurignacian level of Kostenki 1 Layer 3, one publication lists thirteen radiocarbon dates, which are distributed (fairly evenly) between 20,900 ± 1,600 (GIN-4848) and 38,080 +5,460/-3,200 (AA-5590) ^{14}C years BP (Anikovich 2005b). Such wide distributions of radiocarbon dates – which cannot possibly reflect the actual occupation period of a site – mean that the creation of accurate radiocarbon-based chronologies of site occupations or industries is currently an impossible task. No systematic attempt has been made, as it has for Upper Palaeolithic sites on the Yenisei (Graf 2009), to assess the reliability of the published radiocarbon dates from Kostenki-Borshchevo.

Despite this, radiocarbon dates (in combination with attention to stratigraphy and Rogachev's tripartite scheme) have often formed the basis of published attempts to understand the chronology of the region (*e.g*. Anikovich 2005a; Kozłowski 1986; Sinitsyn 2007), which, unfortunately, rarely agree with one another. The differences are not only due to differing uses of radiocarbon dates, but also the lack of consensus on the attribution of various sites to industries, especially in relation to the Gorodtsovian, as seen above.

Long rock shelter sequences are a boon for the archaeology of Western Europe, enabling the construction of detailed chronocultural schemes. Unfortunately, this is not a possibility for European Russia. Although there are multi-layer sites at Kostenki-Borshchevo, the individual sequences are far from complete, and may have been partly eroded or redeposited. Only better absolute dating of each assemblage will allow accurate and detailed chronologies to be created. Currently it seems that the most constructive way forward is to obtain new radiocarbon dates, using the most precise and accurate methods available. Recent results are certainly extremely promising (Douka *et al*. 2010; Marom *et al*. 2012). However, it will take time and resources – and careful attention to excavation history, stratigraphic information, and provenancing of samples – to further elaborate the chronology of the area.

Two Gravettian sites of European Russia

Although there is a reasonable amount of information published on the possible Gravettian sites of the Kostenki-Borshchevo area, the vast majority of it is in Russian. The last comprehensive English-language review of the Kostenki-Borshchevo sites was published by Klein (1969) and was itself heavily dependent on Russian literature mostly published during the 1950s. Two of the most interesting (and largest) possible Gravettian sites at Kostenki-Borshchevo are outlined below, to give an impression of the richness of the archaeology of these sites and the potential for further work. These assemblages are notably under-studied and have received limited attention in the last three decades.

Kostenki 8 (Tel'manskaya) Layer 2

Kostenki 8 (Tel'manskaya) Layer 2 is the only Kostenki assemblage found within the Upper Humic Bed (*i.e.* belonging to Rogachev's second chronological group) that is attributed to the Gravettian. It is located on the second terrace above the Don. The site was discovered in 1936 and was the subject of excavations during 1937, 1949–52, 1958–59, 1962–64, 1976 and 1979 (Rogachev *et al*. 1982). Further, limited work has taken place in the past decade led by V. V. Popov (Bessudnov 2009).

The site contains up to five cultural layers. Layer 2 has been excavated over an area of 530 m^2 (Rogachev *et al*. 1982). It has been claimed that the layout of hearths and accumulations of cultural remains at the site is evidence for five small circular structures, or two small circular structures and one larger one (Rogachev and Anikovich 1984). Hare and wolf predominate among the faunal remains, which also include aurochs, horse, mammoth, reindeer, woolly rhino, red deer, *Megaloceros*, arctic fox, cave bear, birds and fish (*ibid*.).

The lithic assemblage contains 22–23,000 pieces, of which *c.* 2,100 are retouched, including a huge number of backed pieces (*c.* 900, or 43% of the retouched pieces) (Rogachev *et al*. 1982). The assemblage has been described as Early Gravettian/*Gravettien ancien* (Moreau 2010; Otte and Noiret 2003; Sinitsyn 2007), Gravettoid (Anikovich 2005a), "putatively Gravettoid" (Vishnyatsky and Nehoroshev 2004), "Mediterranean-type Gravettian" (Efimenko 1953, 1956 and 1960 cited in Sinitsyn 2007) and, eponymously, "*Thalmannien*" (Djindjian *et al*. 1999). The Early Gravettian attribution is based on the radiocarbon date given below, the site's stratigraphic location within the Upper Humic Bed, and the lithic assemblage. However, no detailed study of the lithic assemblage has yet been carried out (Moreau 2010).

Rogachev *et al.* (1982) have provided the most complete description so far of the assemblage, on which the following summary is based. The assemblage is heavily blade-based, with blades and bladelets forming blanks for the majority of retouched pieces. Imported flint was overwhelmingly used as a raw material and nuclei were, as a rule, worked to exhaustion. There are at least 120 blade and bladelet cores in the assemblage, including *c*. 100 bladelet cores on blades and flakes. Single- and opposed-platformed prismatic cores are represented. Large numbers of unretouched as well as retouched blades were found. The latter group includes burins of various types (*c*. 500 pieces), retouched blades, notched blades, and truncated blades. There are around 50 scrapers in total, including many made on blades. Many of the *c*. 900 backed bladelets and microgravettes are broken. They are all, apparently, extremely small, ranging from 1–5 cm in length and 0.1–0.5 cm in width, but usually around 3 × 0.3 cm (no data on thickness are given). Although the majority of bladelets are backed only along one edge, other varieties of retouch do exist, including complete or partial, marginal or backing retouch on the opposite edge. On some bladelets there is flat ventral retouch on one or both ends. Backing is usually direct, but may be crossing. There are small numbers of 'trapezes' (n=10) and 'segments' (n=14); these are bladelets modified with backing retouch into trapezoidal or arched shapes.

One date on charcoal of 27,700 ± 700 ^{14}C BP (GrN-10509) (Rogachev *et al*. 1982) remains universally cited for this assemblage. Other dates of 24,500 ± 450 ^{14}C BP (GIN-7999), 23,020 ± 320 ^{14}C BP (OxA-7109) and 21,900 ± 450 ^{14}C BP (GrA-9283) have been argued to be erroneous, as they disagree with the usual dating of the Upper Humic Bed (Sinitsyn 1999 cited in Moreau 2010).

The assemblage is widely referred to as the earliest Gravettian assemblage in Russia or, sometimes, in Eastern Europe (*e.g*. Anikovich 2005a; Otte and Noiret 2003; Sinitsyn 2010). Although Sinitsyn (2007) also attributes other Kostenki assemblages to the Gravettian, he stresses the uniqueness of this assemblage within Eastern Europe in the time period between 28–27,000 radiocarbon years ago. Comparisons have been drawn with sites of a similar age elsewhere in Europe. Efimenko (1953, 1956, and 1960 cited in Sinitsyn 2007) believed it was similar to the Grotta Paglicci. Moreau (2010) claims that it differs from the Swabian Early Gravettian, although the precise grounds for this are unclear. Otte and Noiret (2003) suggest an origin for the Moravian MUP at Kostenki 8 Layer 2, based on the shared presence of geometric microliths.

Kostenki 4 (Aleksandrovskaya)

Kostenki 4 is a problematic site. Found on the first terrace, it is placed in the final Kostenki chronological group of sites lying above the Upper Humic Bed. It was discovered in 1927 and further excavated in 1928, 1937–8, 1953 and 1959. In total, 922 m^2 were excavated at the site (Rogachev and Anikovich 1982). Most recently, work has continued on the interpretation of the stratigraphy (Anisyutkin 2006; Zheltova 2009) and on certain aspects of the lithic assemblage (*e.g.* Zheltova 2011).

According to its principal excavator, Rogachev, and as repeated in reviews since, the site contained two layers, which were deposited directly one on top of the other in most areas of the site, but in others had an intermediate sterile layer. The lower layer (Layer 2) contained two lines of hearths surrounded by accumulations of finds, similar to the 'long-houses' of the Kostenki-Avdeevo Culture, while the upper (Layer 1) contained two small round structures. Although the finds horizons were inseparable over most of the site, the raw material and artefact typology were apparently sufficiently different in the areas where they were separated to sort part of the remaining material into collections for each layer (Klein 1969; Rogachev 1955; Rogachev and Anikovich 1982, 1984; Sinitsyn 2007). However, a recent study of the original site documentation has challenged the division of the site into two cultural layers (Zheltova 2009). It found that the layers described as sterile in fact contained finds, and states that there is no way of securely dividing the collection into two layers. Such a conclusion, if correct, perhaps sheds light on why it has been so difficult to assign the upper layer to a particular industry, as seen below.

The following summary of the Layer 1 assemblage is based on Rogachev and Anikovich (1982) where not otherwise stated. According to the published descriptions, the lithic inventory for this layer includes around 16,000 pieces of fine-grained flint (and some quartzite), including around 270 cores and 1,700 retouched pieces. Blade cores are nearly exclusively prismatic: either single-platformed, with removal of blades along the whole perimeter, or double-platformed with removals along part of the perimeter only. There were about 180 bladelet cores on large blades or flakes. Among the retouched pieces, backed bladelets form the largest group, numbering around 400. Usually one edge has straight backing retouch, while the opposite edge is curved and partly retouched at the tip. There are also around 250 burins and 75 scrapers of various types. Interestingly, there are around 190 symmetrical points on blades, with one end bearing semi-steep retouch shaping a point, and the other end worked with dihedral burin removals (Zheltova 2011). Among the remaining lithics are a bifacially-worked leaf-shaped point and shouldered point. Further information about the assemblage, including pieces believed to have been used as pestles or grinding stones, the mobiliary art, and the osseous industry, is available in Klein's (1969) synopsis.

The collection from Layer 2 numbers around 60,000 pieces, including about 250 cores and 7,000 retouched pieces. The blade cores are similar to those described above for Layer 1 (Rogachev and Anikovich 1982). There are around 2,600 backed pieces, which Rogachev and Anikovich (1984) divide into two groups. The first consists of subrectangular backed bladelets sometimes with one or both ends also backed, either straight across or in the form of a notch. The unbacked long edge may be either unworked, with limited retouch towards the ends, or denticulated. Their second group is made up of points, bladelets with backing forming a point at one end. There are about 1,200 splintered pieces, 150 burins and 220 scrapers. The osseous industry includes awls and polishers, and there are pierced teeth of arctic fox and wolf, and perforated mollusc shells (Rogachev and Anikovich 1984).

The available radiocarbon dates for the site currently place it late in the MUP, which agrees with its placement in Rogachev's final chronological group based on its stratigraphic position. They are: 20,290 ± 150 ^{14}C BP (OxA-8310) (Layer not stated) (Bronk Ramsey *et al*. 2002); 22,800 ± 120 ^{14}C BP (GIN-7995) (Layer 1) (Djindjian *et al*. 1999); 23,000 ± 300 ^{14}C BP (GIN-7994) (Layer 1) (*ibid*.)

The Layer 1 assemblage has been described as Gravettian (Djindjian *et al*. 1999), Gorodtsovian (Efimenko 1956, 1958 cited in Sinitsyn 2010), Solutrean (Rogachev 1955) and Aurignacoid (Anikovich 2005a; Anisyutkin 2006), while it has also been said that there are no analogous sites anywhere on the Russian Plain (Rogachev and Anikovich 1984). The animal figurines have been found to be similar or near-identical to those from Kostenki 11 Layer II, although the strong dissimilarity of other aspects of the material culture has also been noted (Rogachev and Anikovich 1984; Sinitsyn 2007). The assemblage from Layer 2 is usually described as Gravettian by Russian authors (Sinitsyn 2007; Zheltova 2009), though the long lines of hearths surrounded by accumulations of artefacts are very comparable to those of the Kostenki-Avdeevo Culture (Djindjian *et al*. 1999).

Incorporation of the Russian record into a European framework

The assemblages outlined above demonstrate some of the variability of the archaeological record just among Gravettian collections; the additional presence of Gorodtsovian, Kostenki-Avdeevo Culture and Epigravettian assemblages must not be forgotten. There are clearly significant differences even just between the groups of backed bladelets found at Kostenki 8–2 and 4–2, which is no surprise given the apparently large difference in age between them. Published descriptions of the other Russian probable Gravettian sites are similarly suggestive of variation and potential for interesting work.

To date, the similarities of Russian MUP archaeology to Western/Central European archaeology have been most obvious in Western discussion of the topic, particularly in studies arguing for widespread, open social networks during this time period. The variability of the Russian record, and the presence of industries that do not currently fit into the Aurignacian-Gravettian classification, has perhaps not yet been fully acknowledged in Western understanding of the European Upper Palaeolithic. Now that the range of cultural diversity within the European MUP is becoming clearer, the time is ripe for a reappraisal of the Russian evidence.

There are, however, certain peculiarities of the Russian record that must be acknowledged before any sort of synthetic approach can be countenanced, some of which have already been mentioned above. The nature of the Russian landscape, with its dearth of caves and rock shelters, has certainly led to differences in the archaeological record, including the original function of sites, taphonomy, and site visibility (Hoffecker 2011). The isolation of the Kostenki-Borshchevo area is another factor to be considered. Although Russian MUP sites are also known outside of this region, they are primarily sites of the Kostenki-Avdeevo Culture; earlier Gravettian industries are apparently restricted to Kostenki-Borshchevo. The distance to the nearest Gravettian sites in Ukraine and, beyond that, Romania and Moravia, poses huge problems for contextualising these assemblages. It is around 600 miles from Kostenki to the nearest major early Gravettian site, at Molodova-5, Ukraine.

Concerning the best approach to the study of Russian lithic assemblages, a few points are worth noting. In order to obtain the necessary typological and technological information for comparison of assemblages, first-hand examination of the collections is essential. Tomášková (2003) has demonstrated (in a comparison of lithic assemblages from Willendorf and Dolní Věstonice) that uncritical comparisons of published outline data of lithic collections can be misleading, particularly when that data was produced in contexts of dissimilar intellectual traditions. As with any other assemblage, full consideration of the excavation and curatorial protocols employed is vital. For the Western archaeologist, this includes an understanding of the differences between Soviet and Western archaeological practice. Finally, for comparisons to be most productive, it makes sense to take account of the large amount of work that has already been done on, for example, bladelet production by colleagues elsewhere in Europe, and to study and record the same features in Russian assemblages.

Conclusions

There is wide interest amongst western European and Anglophone archaeologists in the archaeology of Russia but, to date, work has been piecemeal. Ambitious research, such as that of Soffer (1985), which focused on the archaeology of Ukraine, has shown us a way forward, but has not been followed up by similar work that would flesh out cross-continental comparisons. Many Russian assemblages, even the particularly important ones, have remained under-studied or even entirely unstudied for decades (including by Russian colleagues), representing a huge untapped resource. The potential rewards of intensive study of Russian Upper Palaeolithic assemblages are difficult to estimate but certainly more than justify the difficulties involved.

There are obvious locally-focused questions to be asked of the assemblages, including: which industries and *faciés* thereof made up the Russian MUP? What exactly does the Gorodtsovian represent – an intrusive/local cultural phenomenon, or a reflection of site function, taphonomy, *etc*.? How did the Gravettian change over time? Is there any sign of continuity between the local Gravettian and the Kostenki-Avdeevo Culture, or is the latter more likely to be an intrusive industry? Can the differing geographical distributions of the Kostenki-Avdeevo Culture and other industries be explained? These questions, of course, are debated by Russian colleagues, with varying degrees of consensus on their solutions; they have ramifications for international understanding of Upper Palaeolithic cultural processes.

Broader questions that these data might be used to address include the following. How similar are MUP lithic assemblages across Europe? Did the level of similarity change over time? The MUP saw significant climatic and environmental upheavals – is there any apparent correlation between these changes and changes in the archaeological record? How can the lithic data contextualise our understanding of other aspects of the archaeology, *e.g*. portable art (for example, the late MUP female figurines, often called 'Venus' figurines)? There is an ongoing Western European/Anglophone debate on the purpose of Gravette points and other backed artefacts, especially concerning projectile and bow technology; has Russian evidence and work by Russian colleagues been properly considered in that debate?

It is past time for the full spectrum of the Russian archaeological record to receive the comprehensive international publication and attention it deserves. Presently, the Western understanding of the European Upper Palaeolithic is impoverished by our lack of knowledge of this archaeology and the work of Russian colleagues. The scope for work of benefit to all parties is enormous and, although it presents challenges, it is to be hoped that we can rise to them.

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2. Invisible Individuals, Visible Groups: On the evidence for individuals and groups at the Lower Palaeolithic site of Caddington, Bedfordshire, UK

Frederick W. F. Foulds

Abstract

An emphasis on socially orientated approaches to studying the Palaeolithic has become commonplace. As a result, a "bottom up" approach to interpreting the material record has developed, which emphasises the individual as the appropriate analytical unit. However, this often reduces discussion to "theoretical storytelling", and there is currently no suitable methodology in place to enable the hypotheses brought about by such discourse to be adequately tested. This paper presents research designed to investigate whether the individual is truly a viable unit of analysis within the Lower Palaeolithic. Using an innovative form of analysis centred around the study of flake scar patterning on Acheulean handaxes, the possibilities of tracing individual knappers through Lower Palaeolithic tools from the site of Caddington, Bedfordshire, are explored. The results indicate that a suite of factors collaborate to continually redefine lithic reduction, resulting in any idiosyncrasies present being subsumed within a flexible approach to stone tool manufacture. However, the possibilities of variable group traditions are detected. The implications of this bring into question our ability to produce meaningful dialogues regarding the study of individuals and emphasises that we still do not fully understand how the group influenced Palaeolithic society.

Introduction

The past two decades have seen a flourish in the use of social theory to better understand the Palaeolithic (*e.g.* Dobres 2000; Gamble 2007; Gamble and Gittins 2004; papers in Gamble and Porr 2005; Gravina 2004). Such works aim to shift our analytical perspective, promote the individual[1] as the base unit of analysis and advocate an understanding of the material record in terms of the social relationships that it forges and maintains. This agenda leaves behind the traditional approach of the group, replacing our top-down analysis with one that attempts to form an understanding from the bottom up (Gamble 2007; Gamble and Gittins 2004). Our goal now is to understand how hominins constructed their identities, sustained their relationships, and established themselves within their societies. To do so, it has been suggested that we must fathom the actions of hominins as a means to understand the way they formulated their relationships. It is possible that the traces of such actions can be detected within the material record, which embodies the manner in which hominin agents engaged with the world around them (Ingold 1993).

This approach to understanding the Palaeolithic is not without criticism. The study of the individual in its current state can be considered nothing more than a new rhetorical device that is unfortunately unable to move beyond 'theoretical storytelling' (Hopkinson and White 2005; Pettitt and White 2012; White 2008). The resolution of the record and issues of time depth are also used to argue that studying individual hominins is potentially impossible (Clark 1992). Some have attempted to bypass such difficulties by relying upon the *concept* and *idea* of the individual (such as Mithen 1993), arguing that we do not need to trace specific individuals *per se*, but should instead focus on recognising actions and agency

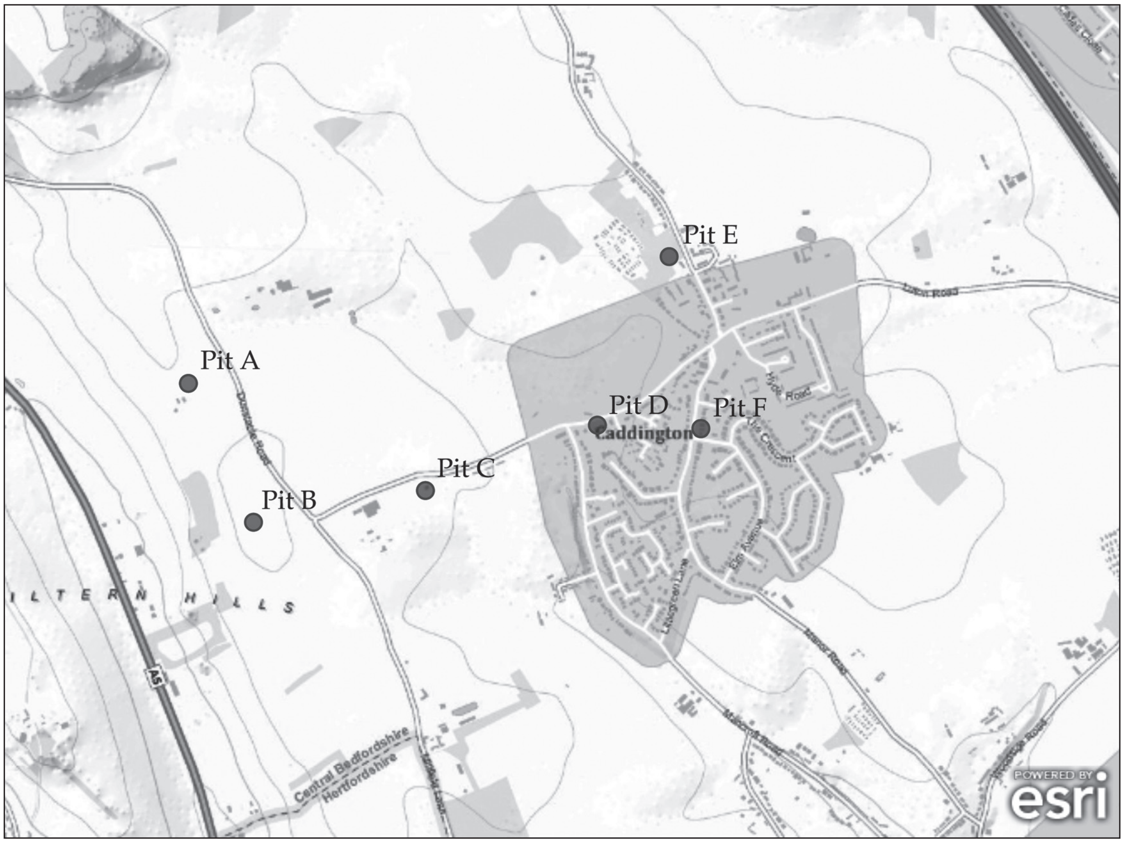

Figure 2.1. A map of the Caddington brickearth pits that Smith recovered Palaeolithic material. The seventh pit (G) is not shown, but Smith (1894) suggests it was southwest of Dunstable.

that can be attributed to individuals (Dobres 2000; cf. Redman 1977). However, others have warned that this will only lead to the construction of axiomatic supra-individuals, the agency of which can only truly be validated, and thus the socially orientated theories on which they rest confirmed, through the analysis of the *observed* individual (Pettitt and White 2012, 161). As a result, we should consider the possibilities of attempting to trace *actual* individuals within the material record to evaluate and substantiate our theories.

The British Lower Palaeolithic and the Individual

The question that now arises is how one actually traces an individual within the Acheulean record. While several studies address the Palaeolithic individual (Dobres 2000; papers in Gamble and Porr 2005; Gravina 2004; Grimm 2000; Pigeot 1990; Schlanger 1990, 1994), few relate to the Lower Palaeolithic and even less discuss methods for tracing individual actors (though see Foulds 2010). Therefore, what can Lower Palaeolithic material culture reveal about hominin individuals and their sociality, given its arguably 'monotonous' technological diversity spread over an extensive geographical and temporal range (Isaac 1972, 1976)?

The British record presents one possible avenue of inquiry. Several British Lower Palaeolithic sites contain tools that display idiosyncrasies outside of usual variation or appear to be the work of individual hominins (Ashton and White 2003; Bradley and Sampson 1978; Pope *et al.* 2006; Porr 2005; White and Plunkett 2004). Caddington, Bedfordshire, is one such site. Situated at the northeastern end of the Chiltern Hills, ~4km west of Luton, it is part of a series of Acheulean sites discovered by Worthington G. Smith in the late nineteenth century (Sampson 1978b; Smith 1889, 1894, 1916). The site itself is composed of tools and debitagé recovered from seven brickearth pits (Figure 2.1), which produced both *in situ* material, as well as 'ocherous' artefacts from what Smith (1894) termed 'contorted drift', representing derived material of currently unknown origin (Bradley and Sampson 1978, 139). Bradley and Sampson (1978) have suggested that four of the handaxes from the Cottages Site (Pit C) are the work of a single individual (Figure 2.2). This,

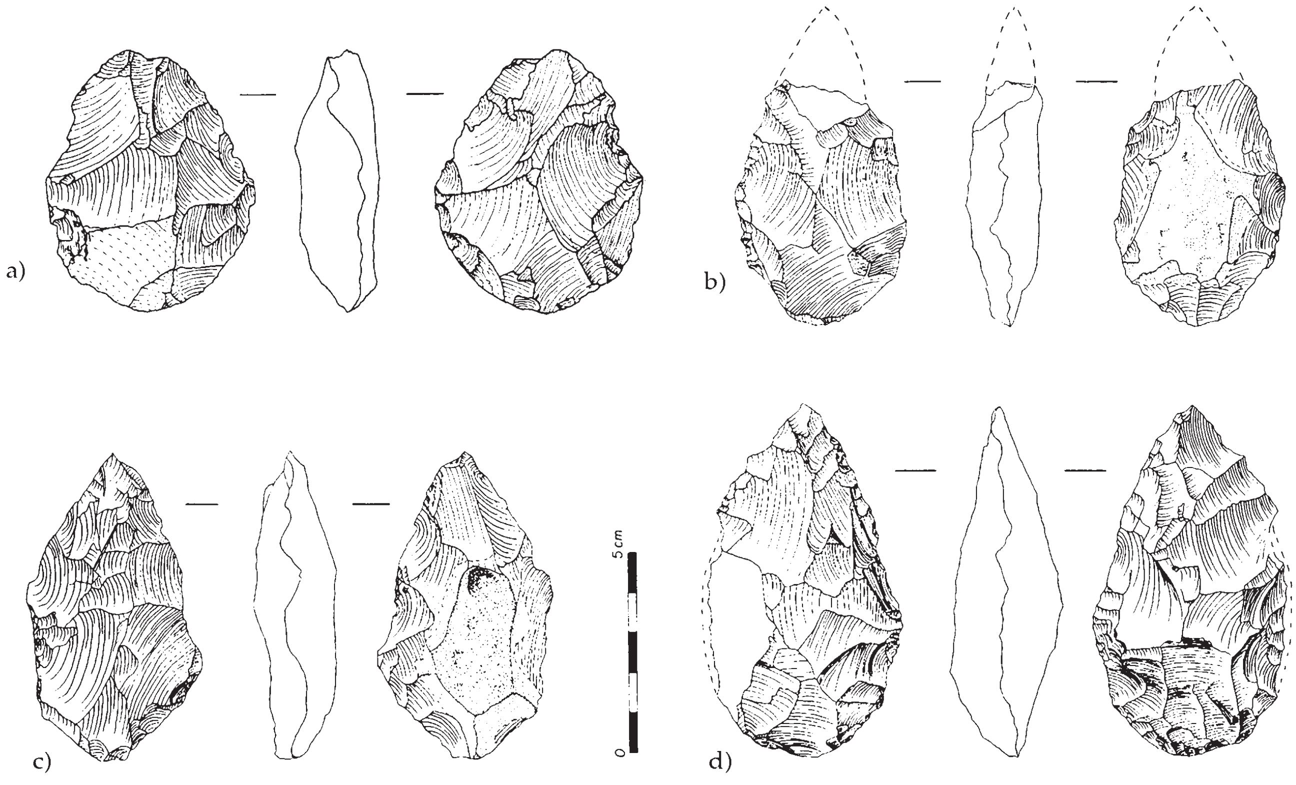

Figure 2.2. Handaxes from Caddington that have been suggested to be the product of the same knapper: a. #1416; b. #1468; c. #1419; d. #1417. Artefact numbers given are after W. G. Smith. Image modified after Sampson (1978a, figure 7.3) (I am grateful to both C. Garth Sampson and Bruce Bradley for their permission to reproduce this figure).

coupled with the *in situ* nature of much of the material and Smith's meticulous record keeping (Campbell and Sampson 1978; White 1997), marks Caddington with the potential for tracing individuals within the Lower Palaeolithic record. This would, if successful, not only allow us to test our theoretical assertions, but further explore the variability present within the Acheulean as a whole.

To trace an individual…

The notion that actual individuals can be traced through their lithic signatures has previously been mooted several times. Gunn (1975, 1977) proposed a methodology for tracing idiosyncrasies by quantifying variation within flake scar patterns on bifacial tools. His methodology employed laser diffraction, also known as optical Fourier analysis, which has seen applications in biology (Oxnard 1973), geology (Davis and Preston 1971; Preston *et al.* 1969) and geography (McCullagh and Davis 1972). Gunn asserted that differences in the intensity of Fourier transform spectra produced by this technique could be attributed to variation in the pattern of flake scars created during tool manufacture (Figure 2.3). His method appeared to demonstrate similarities between the patterns seen within the flake scars on tools and clustered them according to their knappers. As a result, he suggested that there is enough variability in flake scar patterning to separate out some knappers, while other variables, such as skill and experience, influenced the tightness of the clusters produced.

Gunn's experiments are important, not least because they provide a quantitative method that claims to distinguish an individual's products. However, they are not without issue (see Bodu *et al.* 1990; Cross 1983). Furthermore, Gunn analysed a series of replica bifacial tools based on a common template using the same raw material and technique. In imposing these constraints much of the variability that complicates real archaeological assemblages was removed and variability was reduced to that of the individual's involved. This created a bias in the results that overemphasised its suitability for ascertaining individual knappers. Overall, therefore, Gunn's methodology has not been adequately tested, nor systematically applied to archaeological assemblages. Despite these issues, it is currently the

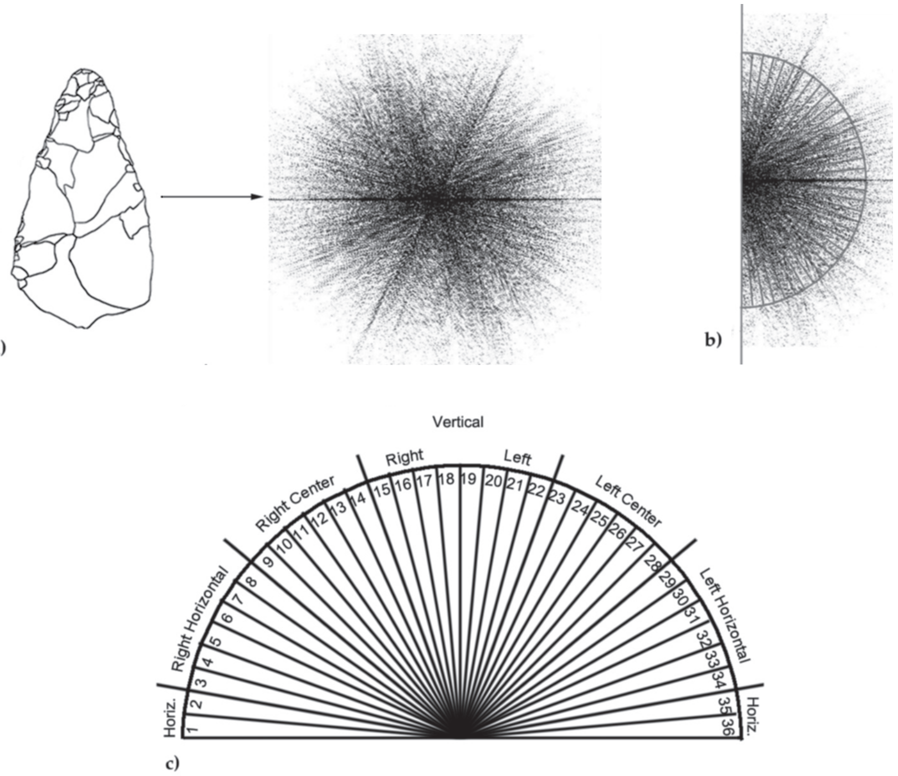

Figure 2.3. Example of the recording system used during the Fourier transform analysis: a. the scar pattern (left) is converted to a Fourier transform spectrum; b. intensity values are calculated for each 5º segment between 0º and 180º, producing thirty-six variables. The full spectrum is not analysed, given its rotational symmetry; c. the thirty-six variables correlate to the orientation of lines in the scar pattern.

only objective method that claims to be able to trace individuals through stone tools, and is thus explored further below.

Methodology

Gunn's methodology favoured physical over digital equipment due to issues surrounding the digitisation of light waves (Oxnard 1973, 176; see Figure 2.4). Advances in computing means this is no longer a complex process. The methodology presented in this paper revised Gunn's method by using a computer program designed to return the two-dimensional discrete Fourier transform of a digital image containing a scar pattern trace, computed using a fast Fourier transform algorithm. To implement the analysis, both sides of a handaxe were photographed and digitally traced. Each of the traces was then converted to a 500 by 500 pixel image to remove variability in size. The computer program was then used to convert each of the trace images into Fourier transform spectra and calculate intensity values across a 180º arc divided into five-degree segments. This produced data across a total of thirty-six variables, which are comparable to those produced in Gunn's analysis. Only half of the spectrum was analysed in each case, due to the fact that the spectra display rotational symmetry. The extracted data were then interrogated using principal component analysis to extract components accounting for the majority of the variance. These components were then plotted as scatter diagrams to explore the data further.

Materials

Exploring individuals in the archaeological record is, of course, fraught with difficulties, not least because we cannot make *a priori* assumptions about the identity of the individuals we are trying to trace. Therefore, to 'test' the methodology described above, a control group was created, comprising twenty-six replica handaxes created by several skilled knappers (Table 2.1). Minimal constraints were placed on this assemblage to explore whether other forms of variability, such as raw material, shape and size, have a greater signature than knapping idiosyncrasies. Knappers freely selected the tool forms

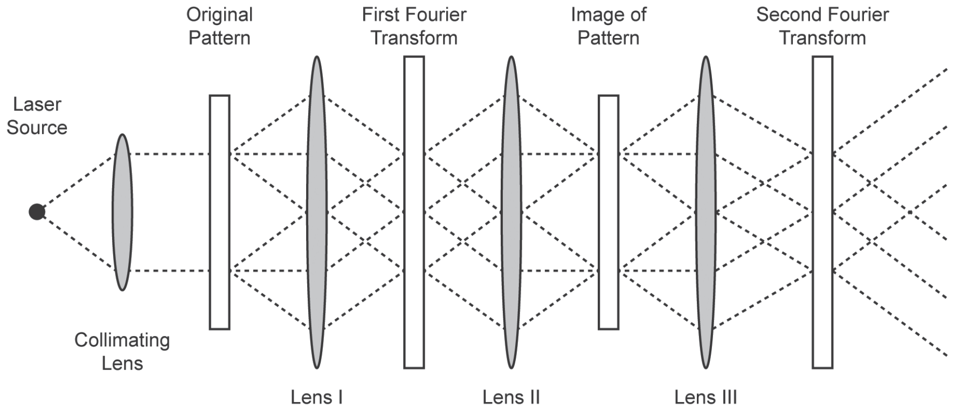

Figure 2.4. Example of the equipment setup used by Gunn (redrawn after Oxnard 1973, figure 114). Laser light passes through the original pattern (in this case a photonegative of a scar pattern trace), followed by a series of lens and Fourier transforms, before the simplified waveform is analysed.

Handaxe No.	Knapper	B/L	B1/B2	L1/L	Roe's Shape
1	1	0.773	0.727	0.409	Ovate
2	1	0.740	0.857	0.457	Ovate
3	2	0.500	0.569	0.236	Point
4	3	0.524	0.979	0.507	Ovate
5	2	0.688	0.806	0.421	Ovate
6	2	0.574	0.483	0.195	Point
7	4	0.473	0.954	0.433	Ovate
8	1	0.793	0.805	0.359	Ovate
9	5	0.707	0.702	0.309	Point
10	1	0.600	0.966	0.354	Ovate
11	2	0.506	0.655	0.317	Point
12	2	0.677	0.925	0.440	Ovate
13	6	0.749	0.952	0.385	Ovate
14	4	0.722	0.799	0.385	Ovate
15	1	0.689	0.978	0.432	Ovate
16	4	0.625	0.567	0.308	Point
17	5	0.529	0.751	0.311	Point
18	2	0.648	0.927	0.380	Ovate
19	5	0.623	0.618	0.340	Point
20	1	0.833	0.952	0.415	Ovate
21	4	0.698	0.839	0.436	Ovate
22	4	0.721	0.785	0.467	Ovate
23	1	0.621	0.564	0.269	Point
24	2	0.686	0.790	0.305	Point
25	4	0.635	0.830	0.431	Ovate
26	1	0.561	0.556	0.279	Point

Table 2.1. List of replica assemblage handaxes, including measurements and typological data based on Roe (1968).

they created, an approach that allowed for testing of whether a knapper's idiosyncratic technique transcends the shape of the finished product. Furthermore, this enabled the extent to which forcing knappers to conform to a set example, as Gunn did, might introduce a bias into the results.

Following the replica handaxes, the assemblages from the site of Caddington were analysed. A total of sixty-six handaxes were studied from five of the brickearth pits. Although it is not possible to ascribe every handaxe to its pit of origin (Roe 1981), an effort was made to provenance each artefact using Smith's (n.d.) 'List of Palaeolithic Implements'. Five of the artefacts studied were listed as 'no fixed provenance', indicating which cannot be traced back to a specific pit. Two of these still retained Smith's find numbers and are attributed to the initial finds from behind Dunstable Grammar School (Smith 1889; 1894, 93; n.d.). According to Smith (1894, 94), gravels were sent to Dunstable from both Pit B and C at Caddington. However, it is impossible to accurately attribute the handaxes to these pits. Therefore, no attempt was made to associate them to a specific find spot and they, along with the other unprovenanced artefacts, were not included in the analysis presented here. In addition, as the majority of sites from the Chiltern Hills are formed in solution hollows in the underlying chalk, it is possible that the pits Smith studied are in fact separate instances of Palaeolithic activity of different ages. The remaining handaxes were thus divided according to the brickearth pits from which they were recovered (Table 2.2). No attempt has been made to differentiate between the contorted drift and Palaeolithic floor assemblages, although this has been done elsewhere (Foulds 2012).

Handaxe No.	Pit	B/L	B1/B2	L1/L	Roe Shape
1398	A	0.548	0.686	0.281	Point
1400	F	0.755	0.880	0.379	Ovate
1416	C	0.823	0.906	0.469	Ovate
1417	C	0.494	0.726	0.426	Ovate
1418	C	0.613	0.991	0.412	Ovate
1419	C	0.561	0.924	0.361	Ovate
1421	A	0.711	0.806	0.568	Ovate
1428	C	0.617	0.702	0.469	Ovate
1431	C	0.734	0.799	0.396	Ovate
1439	C	0.703	0.917	0.443	Ovate
1440	A	0.563	0.518	0.160	Point
1441	A	0.654	0.842	0.483	Ovate
1454	C	0.679	0.990	0.620	Ovate
1468	C	0.686	1.275	0.422	Ovate
1478	A	0.868	0.744	0.420	Ovate
1496	C	0.542	0.718	0.356	Ovate
1514	C	0.671	0.716	0.396	Ovate
1515	C	0.687	0.626	0.331	Point
1531	A	0.512	0.643	0.269	Point
1532	A	0.686	0.568	0.428	Ovate
1537	A	0.689	0.675	0.365	Ovate
1545	A	0.472	1.332	0.574	Ovate
1555	A	0.651	0.589	0.248	Point
1562	C	0.652	0.679	0.375	Ovate
1563	A	0.699	0.842	0.453	Ovate
1571	C	0.518	1.161	0.543	Ovate
1583	A	0.815	1.031	0.472	Ovate
1598	A	0.701	0.794	0.442	Ovate
1599	A	0.702	1.104	0.605	Ovate
1602	E	0.720	0.744	0.452	Ovate
1614	E	0.641	0.525	0.273	Point
1615	F	0.640	0.900	0.431	Ovate
1616	E	0.518	0.857	0.305	Point
1619	E	0.758	0.921	0.439	Ovate
1637	E	0.559	0.493	0.265	Point
1639	E	0.797	0.608	0.375	Ovate
1643	C	0.758	0.726	0.383	Ovate
1647	C	0.619	0.865	0.274	Point
1648	C	0.736	0.775	0.529	Ovate
1655	C	0.770	0.726	0.378	Ovate
1659	C	0.741	0.906	0.473	Ovate
1661	F	0.656	1.008	0.458	Ovate
1688	C	0.730	0.393	0.263	Point
1697	C	0.571	0.664	0.354	Ovate
1705	C	0.704	0.878	0.443	Ovate
1706	C	0.648	0.864	0.438	Ovate
1709	F	0.717	0.631	0.407	Ovate
1713	F	0.594	1.051	0.373	Ovate
1715	G	0.624	0.653	0.380	Ovate
1718	G	0.691	0.795	0.382	Ovate
1719	G	0.599	0.884	0.462	Ovate
1722	F	0.784	0.938	0.584	Ovate
1723	C	0.667	0.774	0.360	Ovate
1724	C	0.639	0.652	0.284	Point
1725	C	0.624	0.559	0.239	Point
1726	F	0.850	0.899	0.507	Ovate
1727	C	0.554	0.785	0.368	Ovate
1729	C	0.852	0.647	0.301	Point
1731	C	0.560	1.102	0.547	Ovate
1732	C	0.711	0.554	0.198	Point
1740	E	0.753	0.508	0.312	Point
1766	A	0.621	0.826	0.275	Point

Table 2.2. List of handaxes from the Caddington assemblages, including the pits from which they were recovered from, as well as typological information based on Roe (1968).

Analysis and results

For both the experimental and archaeological sample, scar patterns from both surfaces of each handaxe were traced and processed using Fourier transform analysis. In both cases the surface data was analysed separately, as well as combined so patterning across the whole tool could be explored. Analysis was conducted in SPSS (release 17.0.0) using a combination of principal component (PCA) and hierarchical cluster analysis, the results of which were used to determine whether handaxes grouped according to the individual who created them, or other factors.

The replica assemblage

The PCA results produced five components with eigenvalues greater than 1.0 from both the surface and combined data, which explained 81.44% and 89.04% of the variance respectively (Tables 2.3 to 2.6). However, the analysis of the combined data produced negative eigenvalues, probably owing to the limited number of cases (n=26) compared to the variables under study (n=36). Therefore, the results from the combined data can only be interpreted tentatively, although they show good correlation with those from the surface data.

The results were plotted as scatter diagrams, using

Total Variance Explained

Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	17.113	47.536	47.536	17.113	47.536	47.536
2	4.797	13.324	60.86	4.797	13.324	60.86
3	4.256	11.823	72.682	4.256	11.823	72.682
4	2.012	5.589	78.272	2.012	5.589	78.272
5	1.141	3.169	81.441	1.141	3.169	81.441
6	0.937	2.602	84.043			
7	0.692	1.923	85.966			
8	0.553	1.535	87.501			
9	0.545	1.513	89.014			
10	0.504	1.401	90.415			
11	0.409	1.135	91.551			
12	0.379	1.053	92.603			
13	0.344	0.955	93.559			
14	0.3	0.832	94.391			
15	0.24	0.666	95.056			
16	0.231	0.643	95.699			
17	0.203	0.565	96.264			
18	0.176	0.49	96.754			
19	0.172	0.478	97.232			
20	0.147	0.409	97.641			
21	0.136	0.377	98.018			
22	0.117	0.324	98.342			
23	0.098	0.273	98.615			
24	0.091	0.253	98.868			
25	0.083	0.23	99.098			
26	0.059	0.165	99.263			
27	0.051	0.141	99.404			
28	0.043	0.119	99.523			
29	0.037	0.103	99.626			
30	0.031	0.087	99.713			
31	0.029	0.08	99.793			
32	0.025	0.069	99.861			
33	0.018	0.05	99.911			
34	0.016	0.043	99.954			
35	0.013	0.035	99.989			
36	0.004	0.011	100			

Table 2.3. The results of the principal component analysis applied to the replica assemblage surface data.

typological data based on Roe's (1968) method to differentiate shape (Figure 2.5 and 2.6). These display a clear division of the handaxes based on outline morphology, especially where component one and two are concerned, suggesting that these simply highlight the *overall shape* of the handaxes. It is also notable that ovates remain tightly clustered compared to points, suggesting greater variation within the scar patterns on pointed tools. Additionally, while clustering of opposing surfaces from the same tool is not prevalent, this is more common amongst ovates, indicating a higher degree of similarity in scar patterning across both faces. However, the majority of handaxes show little clustering of associated surfaces. This demonstrates differences in the progression of the thinning strategy applied to each face. It is also noted that points often display dominance of a particular line orientation within their scar pattern. It is possible that this is

		Component Matrix				
		Component				
		1	*2*	*3*	*4*	*5*
Horizontal	V1	0.489	0.656	-0.305	-0.058	0.214
	V2	0.586	0.448	-0.57	-0.021	0.024
Right Horizontal	V3	0.617	0.39	-0.575	0.021	-0.115
	V4	0.655	0.295	-0.604	0.03	-0.181
	V5	0.657	0.196	-0.544	0.035	-0.281
	V6	0.729	-0.162	-0.3	0.266	-0.163
	V7	0.7	-0.317	-0.33	0.211	0.079
	V8	0.722	-0.376	-0.233	0.313	-0.037
Right Centre	V9	0.669	-0.413	-0.203	0.448	0.05
	V10	0.692	-0.418	-0.151	0.362	0.116
	V11	0.648	-0.4	-0.073	0.416	0.361
	V12	0.776	-0.265	0.099	0.155	0.308
	V13	0.734	-0.215	0.227	0.149	0.139
	V14	0.764	-0.071	0.152	0.237	-0.208
Vertical	V15	0.678	0.102	0.436	0.173	-0.185
	V16	0.668	0.253	0.437	0.105	-0.266
	V17	0.686	0.378	0.233	0.306	0.118
	V18	0.448	0.602	0.541	0.054	0.025
	V19	0.37	0.651	0.32	0.044	0.416
	V20	0.466	0.611	0.371	-0.085	0.304
	V21	0.66	0.415	0.354	0.127	-0.008
	V22	0.709	0.368	0.395	0.186	-0.133
Left Centre	V23	0.687	0.238	0.438	0.021	-0.304
	V24	0.811	-0.075	0.315	-0.129	-0.024
	V25	0.773	-0.207	0.359	-0.117	-0.233
	V26	0.833	-0.279	0.177	-0.121	-0.101
	V27	0.728	-0.295	0.306	-0.276	-0.11
	V28	0.679	-0.369	0.215	-0.496	0.117
Left Horizontal	V29	0.74	-0.402	0.166	-0.39	0.015
	V30	0.769	-0.346	0.004	-0.336	0.066
	V31	0.806	-0.318	-0.033	-0.293	0.134
	V32	0.764	-0.274	-0.098	-0.193	0.104
	V33	0.76	-0.031	-0.319	-0.258	0.006
	V34	0.781	0.131	-0.3	-0.308	0.078
Horizontal	V35	0.651	0.386	-0.45	-0.166	-0.046
	V36	0.641	0.526	-0.409	-0.206	0.06

Table 2.4. The component matrix from the analysis of the replica assemblage surface data, displaying loadings for each extracted components.

Total Variance Explained

Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	20.724	57.565	57.565	20.724	57.565	57.565
2	5.698	15.828	73.393	5.698	15.828	73.393
3	2.622	7.283	80.676	2.622	7.283	80.676
4	1.954	5.429	86.105	1.954	5.429	86.105
5	1.055	2.931	89.036	1.055	2.931	89.036
6	0.838	2.327	91.363			
7	0.547	1.519	92.882			
8	0.505	1.403	94.284			
9	0.397	1.103	95.388			
10	0.266	0.739	96.126			
11	0.236	0.656	96.783			
12	0.206	0.573	97.356			
13	0.173	0.481	97.836			
14	0.159	0.441	98.277			
15	0.125	0.348	98.625			
16	0.088	0.245	98.87			
17	0.088	0.244	99.114			
18	0.086	0.238	99.352			
19	0.076	0.21	99.562			
20	0.049	0.136	99.698			
21	0.038	0.104	99.802			
22	0.028	0.077	99.879			
23	0.027	0.075	99.955			
24	0.011	0.03	99.985			
25	0.005	0.015	100			
26	0	0	100			
27	0	0	100			
28	0	0	100			
29	0	0	100			
30	0	0	100			
31	0	0	100			
32	0	0	100			
33	0	0	100			
34	0	0	100			
35	0	0	100			
36	0	0	100			

Table 2.5. The results of the principal component analysis applied to the replica assemblage combined data.

caused by differences in the knapping strategy applied (Figure 2.7). Ovate tools are often produced using a circumferential reduction strategy, resulting in a greater variation in flake scar orientation. Extensive thinning also increases the number of flake scars present. As a result a greater combination of line orientations is seen within the scar patterns. Pointed tools, on the other hand, display high levels of thinning to the tip, while the butt shows limited flaking. This results in lower variability of line orientation due to the limited number of removals. This may lead to one orientation dominating. If this is correct, then the desired form of a handaxe will, to a certain extent, dictate the scar pattern present on finished tools and explain why these results strongly correlate with shape.

Cluster analysis of the PCA results from the combined data was used to test whether handaxes grouped according to the knappers who produced them. When

		Component Matrix				
		Component				
		1	*2*	*3*	*4*	*5*
Horizontal	V1	0.624	0.655	-0.141	0.091	0.223
	V2	0.675	0.459	-0.459	0.042	0.057
Right Horizontal	V3	0.676	0.469	-0.484	-0.041	0.001
	V4	0.782	0.411	-0.395	-0.059	-0.053
	V5	0.823	0.263	-0.224	0.096	-0.357
	V6	0.774	-0.132	-0.045	0.319	-0.379
	V7	0.766	-0.281	-0.235	0.398	-0.194
	V8	0.759	-0.419	-0.061	0.336	-0.235
Right Centre	V9	0.643	-0.533	-0.06	0.426	0.103
	V10	0.674	-0.531	-0.09	0.347	0.152
	V11	0.631	-0.524	-0.129	0.442	0.219
	V12	0.78	-0.419	0.106	0.126	0.309
	V13	0.755	-0.318	0.118	0.118	0.344
	V14	0.811	-0.096	0.21	0.123	0.044
Vertical	V15	0.775	0.033	0.455	0.102	-0.203
	V16	0.757	0.189	0.38	-0.024	-0.249
	V17	0.792	0.367	0.168	0.286	-0.006
	V18	0.541	0.621	0.456	-0.014	-0.114
	V19	0.517	0.66	0.217	0.194	0.288
	V20	0.592	0.64	0.238	0.108	0.135
	V21	0.764	0.401	0.321	0.105	0.086
	V22	0.819	0.344	0.349	-0.029	0.057
Left Centre	V23	0.776	0.194	0.464	-0.122	-0.073
	V24	0.91	-0.152	0.155	-0.15	0.093
	V25	0.8	-0.31	0.252	-0.315	-0.083
	V26	0.861	-0.322	0.06	-0.199	0.017
	V27	0.762	-0.363	0.246	-0.368	0.023
	V28	0.736	-0.415	-0.074	-0.463	0.105
Left Horizontal	V29	0.763	-0.429	0.006	-0.394	0.1
	V30	0.835	-0.353	-0.074	-0.212	-0.096
	V31	0.884	-0.302	-0.171	-0.196	-0.008
	V32	0.905	-0.205	-0.214	-0.117	-0.07
	V33	0.86	-0.03	-0.218	-0.141	-0.187
	V34	0.858	0.162	-0.286	-0.107	0.082
Horizontal	V35	0.71	0.397	-0.435	-0.2	0.097
	V36	0.712	0.574	-0.321	-0.115	0.043

Table 2.6. The component matrix from the analysis of the replica assemblage combined data, displaying loadings for each extracted components.

compared to the typological information, it is clear that the suggested groupings are primarily based on shape and are highly reliant on components one and two (Figure 2.8). It is unlikely that cluster analysis is able to attribute tools to their creators, although tools made by Knapper 1 and Knapper 2 do cluster to a certain extent, especially with regard to component four and five (see Figure 2.9). While this does not immediately differentiate these handaxes from the rest of the assemblage, it suggests conformity to a specific shape and pattern of reduction that is not readily apparent amongst the other knappers. However, these individuals contributed the majority of the handaxes in the assemblage. Therefore, it is possible that a bias in the construction of the assemblage prevents patterning being seen amongst the other knappers due to the fact that they contributed fewer tools.

Overall, the analysis of the replica assemblage

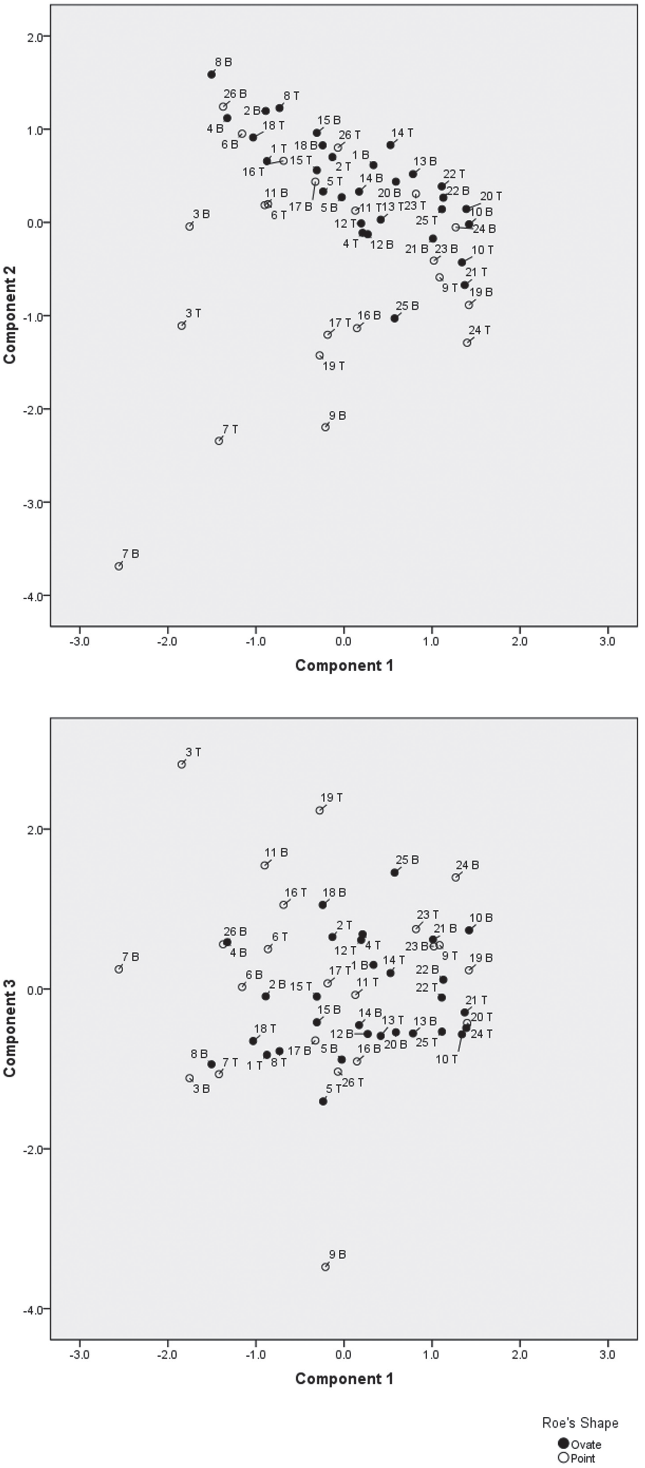

Figure 2.5a. Plots from the analysis of the replica assemblage surface data (T = Top, B = Bottom). Top: component one versus two; bottom: component one versus three. The handaxes are differentiated by shape, based on Roe's (1968) typology.

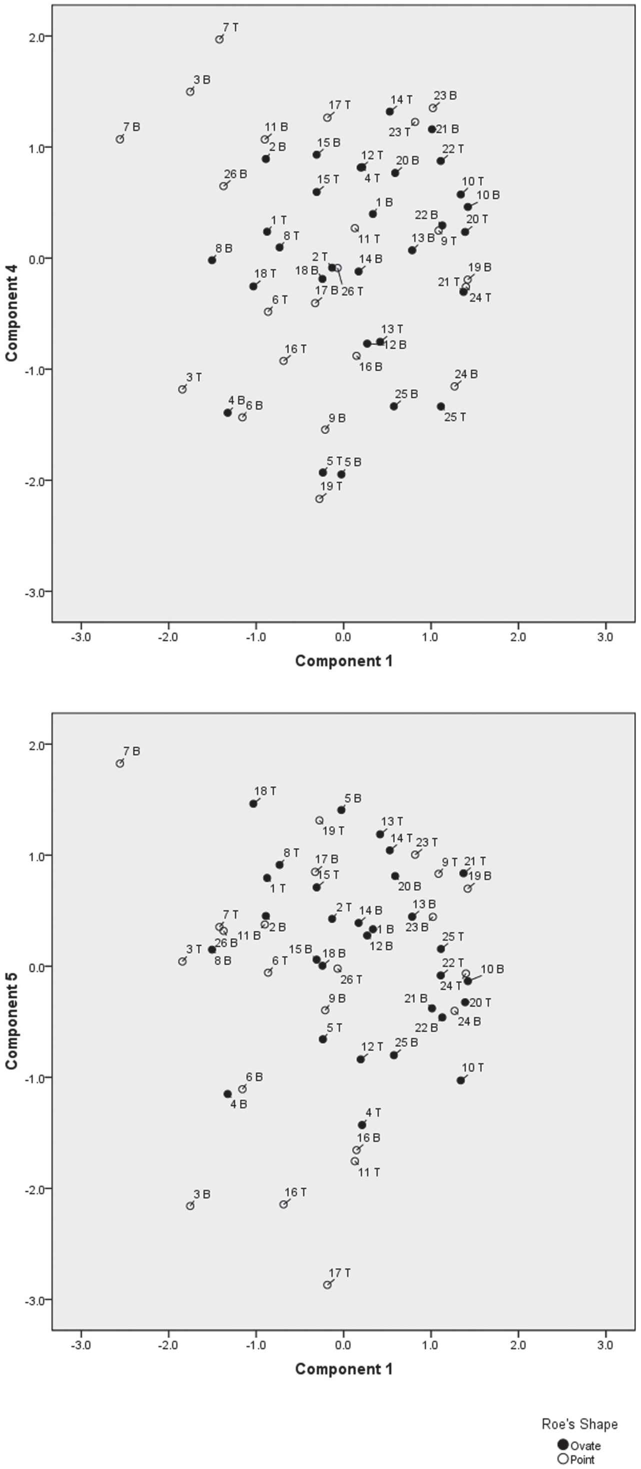

Figure 2.5b. Plots from the analysis of the replica assemblage surface data. Top: component one versus four; bottom: component one versus five. The handaxes are differentiated as per Figure 2.5a.

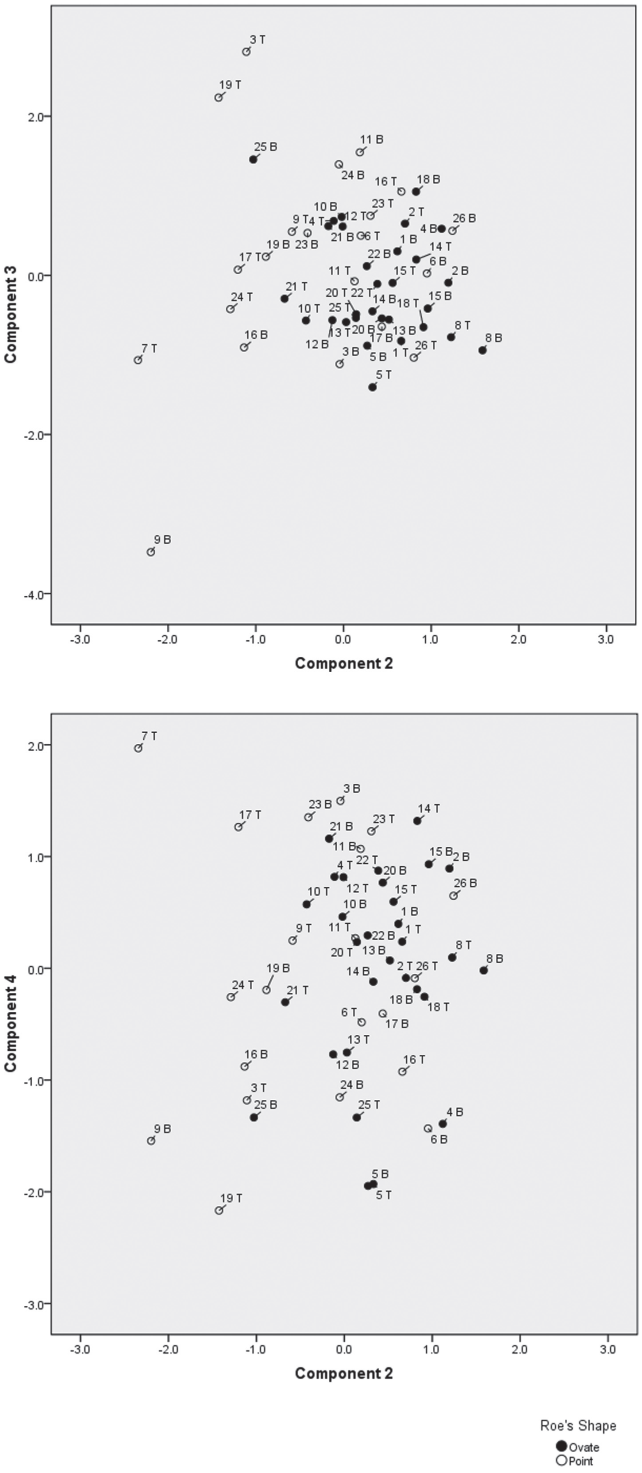

Figure 2.5c. Plots from the analysis of the replica assemblage surface data. Top: component two versus three; bottom: component two versus four. The handaxes are differentiated as per Figure 2.5a.

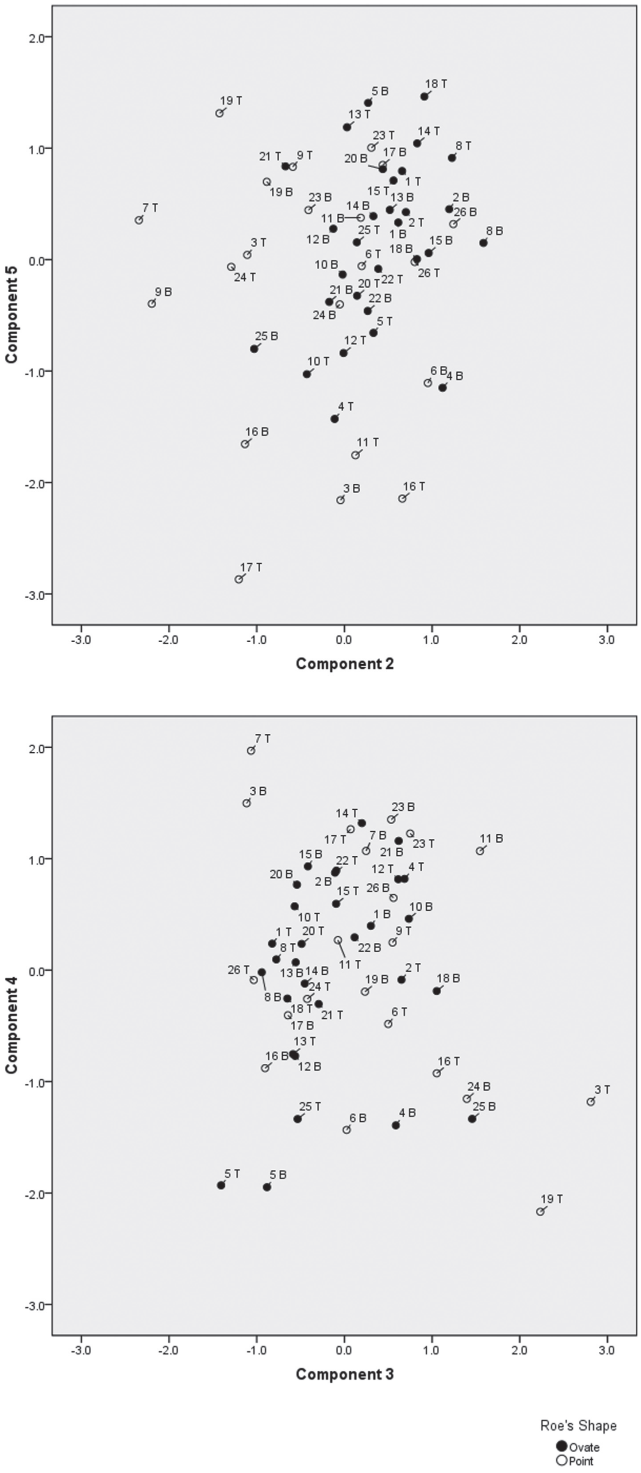

Figure 2.5d. Plots from the analysis of the replica assemblage surface data. Top: component two versus five; bottom: component three versus four. The handaxes are differentiated as per Figure 2.5a.

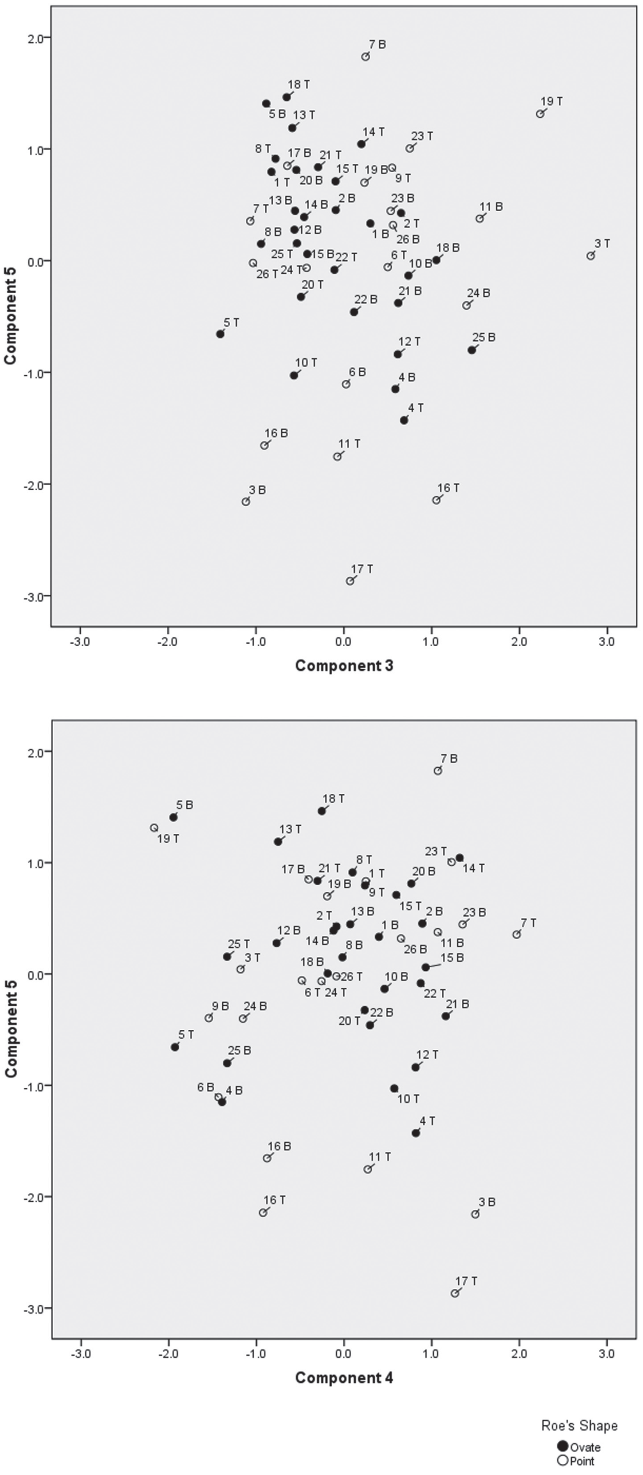

Figure 2.5e. Plots from the analysis of the replica assemblage surface data. Top: component three versus five; bottom: component four versus five. The handaxes are differentiated as per Figure 2.5a.

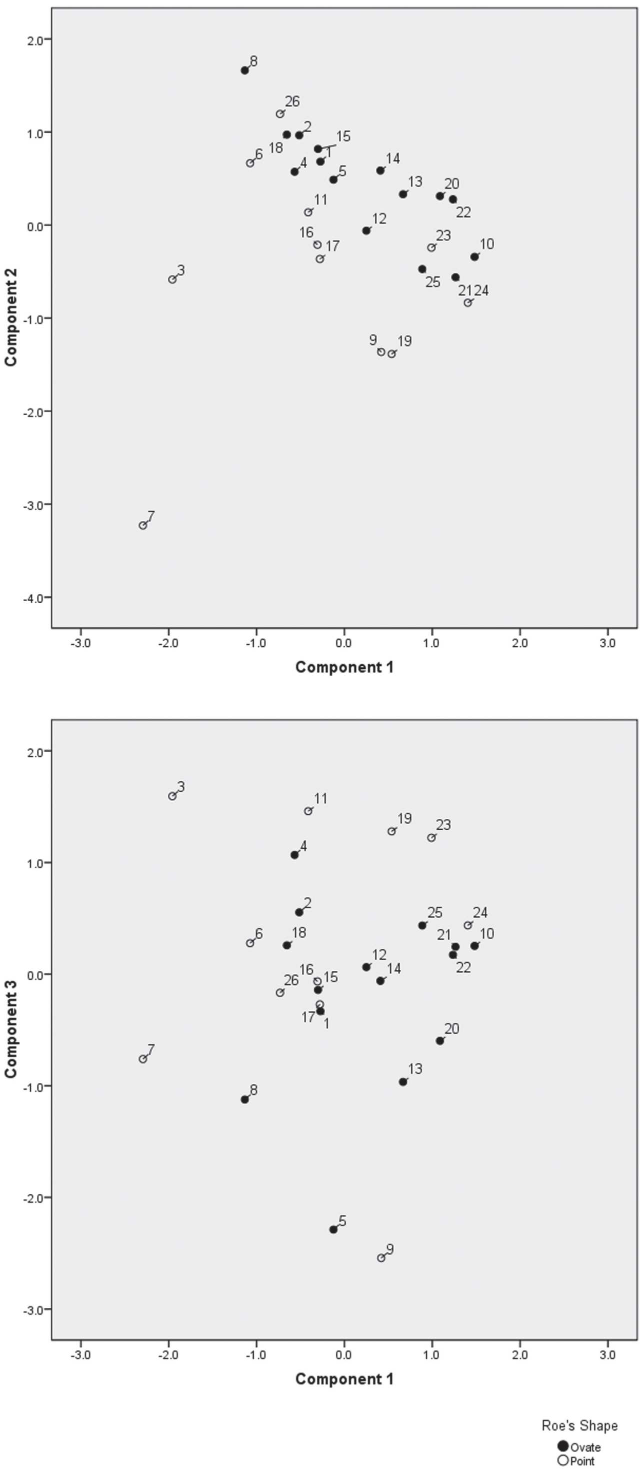

Figure 2.6a. Plots from the analysis of the replica assemblage combined data. Top: component one versus two; bottom: component one versus three. The handaxes are differentiated by shape, based on Roe's (1968) typology.

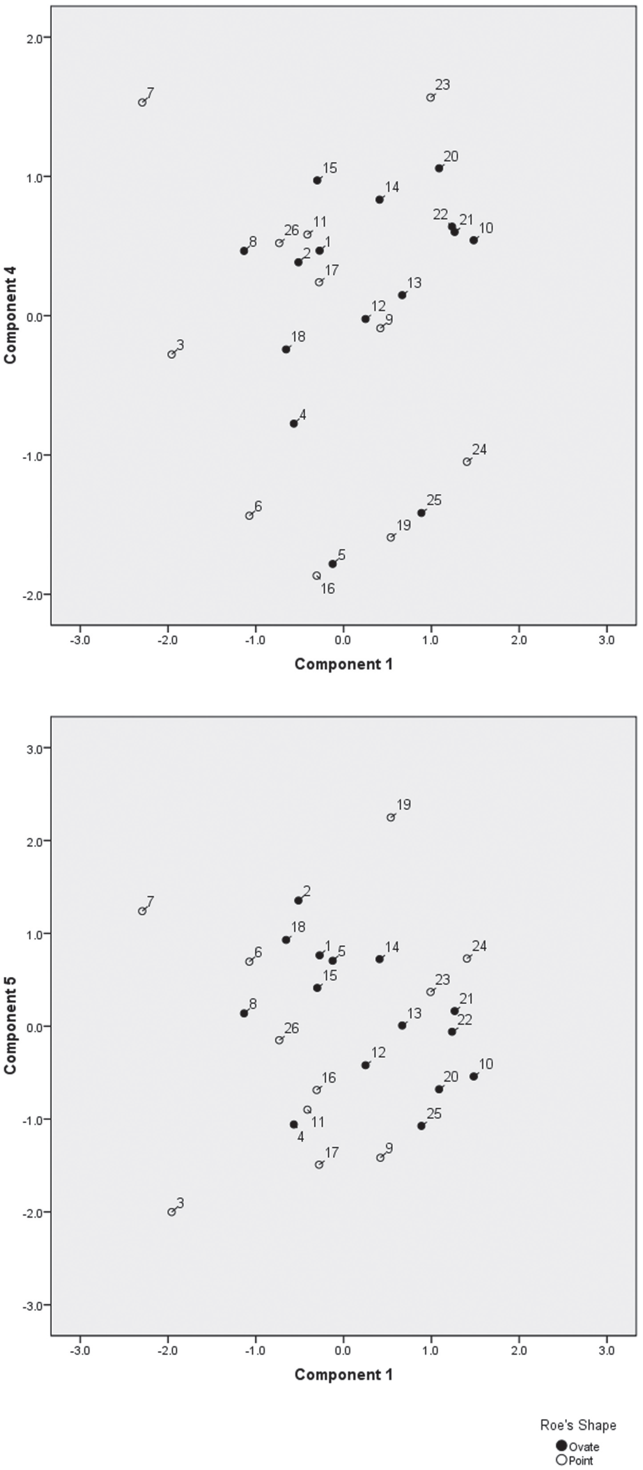

Figure 2.6b. Plots from the analysis of the replica assemblage combined data. Top: component one versus four; bottom: component one versus five. The handaxes are differentiated as per Figure 2.6a.

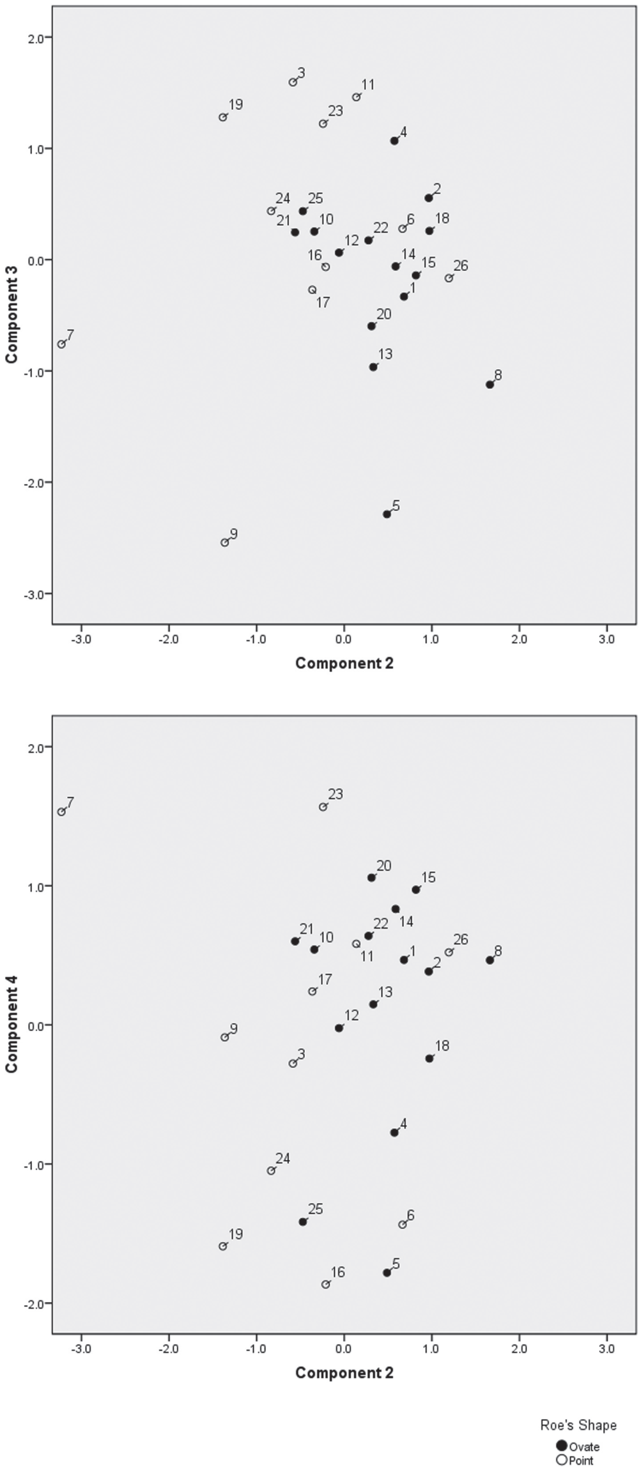

Figure 2.6c. Plots from the analysis of the replica assemblage combined data. Top: component two versus three; bottom: component two versus four. The handaxes are differentiated as per Figure 2.6a.

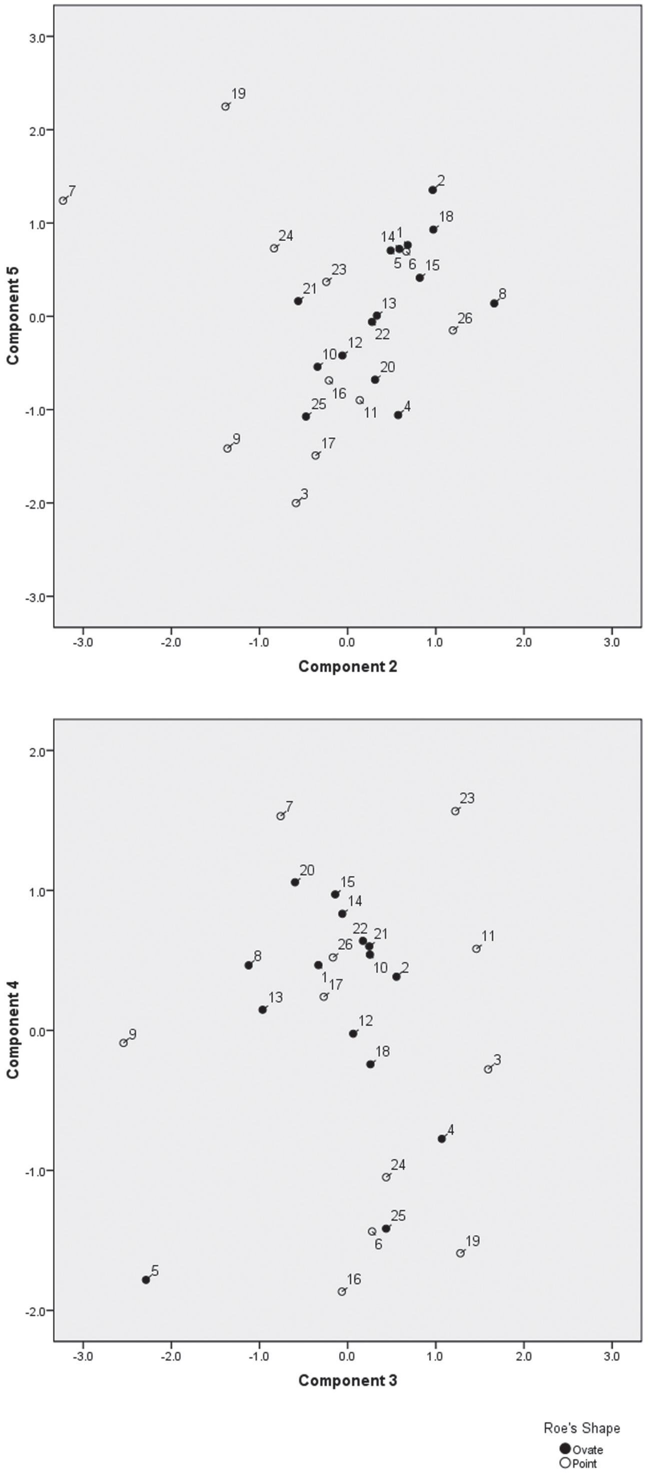

Figure 2.6d. Plots from the analysis of the replica assemblage combined data. Top: component two versus five; bottom: component three versus four. The handaxes are differentiated as per Figure 2.6a.

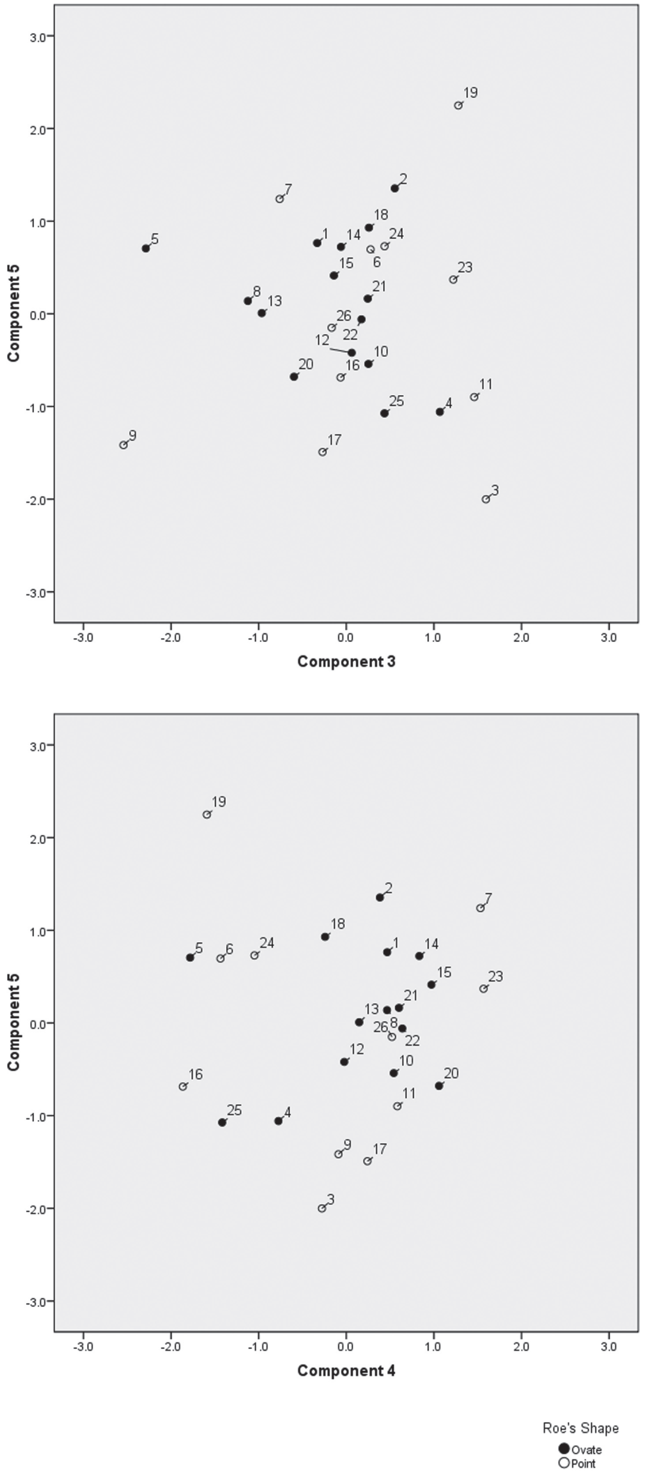

Figure 2.6e. Plots from the analysis of the replica assemblage combined data. Top: component three versus five; bottom: component four versus five. The handaxes are differentiated as per Figure 2.6a.

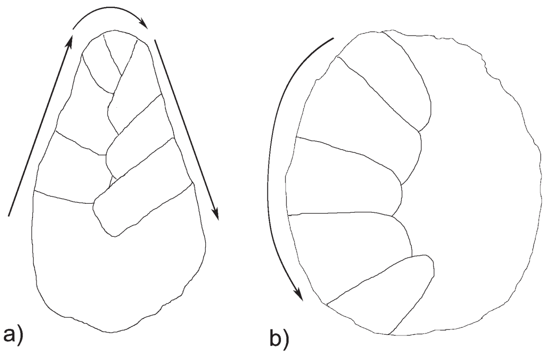

Figure 2.7. A simplified example of the differences between pointed and ovate thinning strategies: a. points are worked along the edge, with removals truncating previous scars, resulting in increased vertically and horizontally orientated lines in the scar pattern; b. ovates display circumferential working, leading to a greater diversity in line orientation.

indicates that variation within and between scar patterns is complex and that the majority of the variance relates to differences in shape. The results also demonstrate the inability of the technique to trace significant idiosyncratic patterning within flake scars. The reasons for this are suggested to be the heavy influence of shape in governing and restricting flake scar morphology and, by extension, the reduction techniques used. While it is understood that each individual will contribute to the total variation according to the choices they make, it appears that these choices are not so much reflections of the individual's abilities, *per se.* Rather they are flexible responses to producing a desired end product. However, the fact that Knapper 1's tools show a high degree of similarity suggests that preference for a specific shape and, by extension, a learned reduction strategy may delineate the final form of some tools.

The Caddington assemblage

Despite the failure to attribute replica handaxes to their knappers, it is important to highlight both similarities and differences between the replica and archaeological material through the analysis of the Caddington assemblage. However, as the hierarchical cluster analysis was unable to group tools according to their knappers, this technique was not applied.

The PCA extracted just two components with eigenvalues greater than 1.0 from the surface data (Table 2.7 and 2.8), and only a single component from the combined data (Table 2.9 and 2.10). These results explain 91.85% and 92.64% of the variance in each sample respectively. To enable further analysis of the combined data, a second component with an eigenvalue

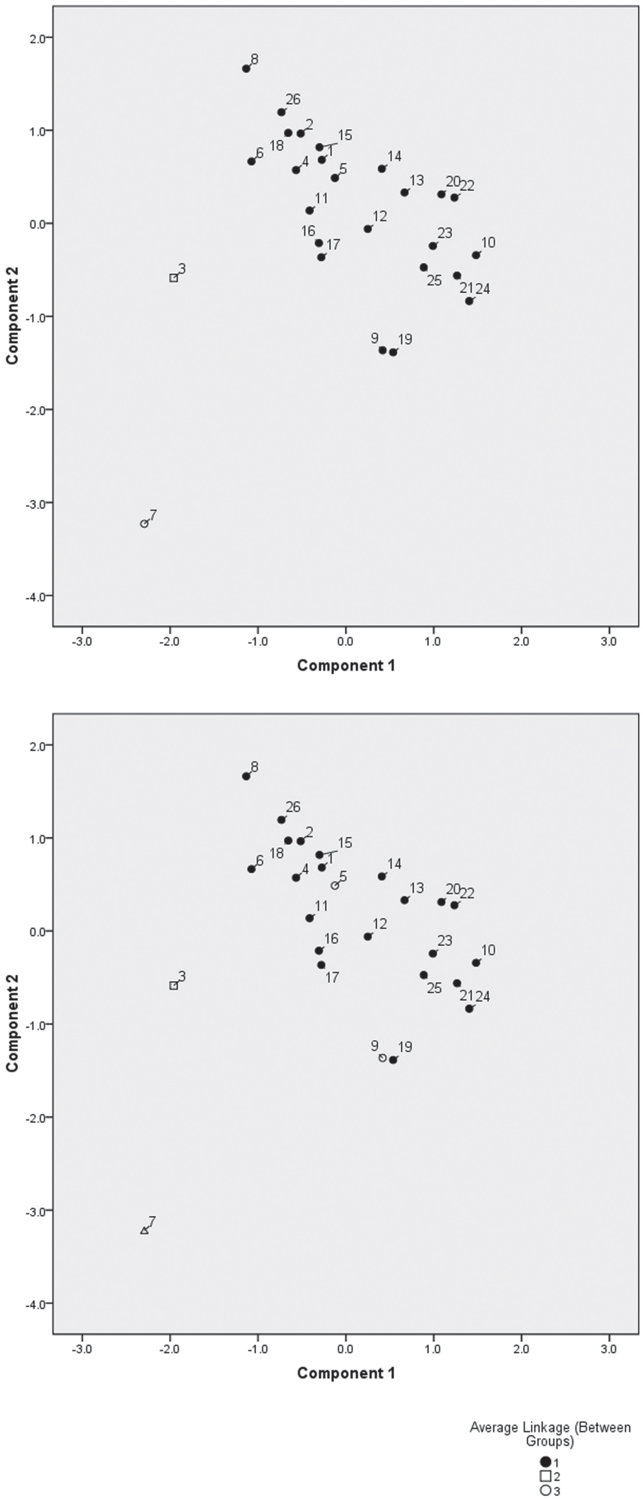

Figure 2.8a. Plots of component one and two from the analysis of the combined data, with handaxes grouped according to the cluster analysis. Top: three clusters; bottom: four clusters.

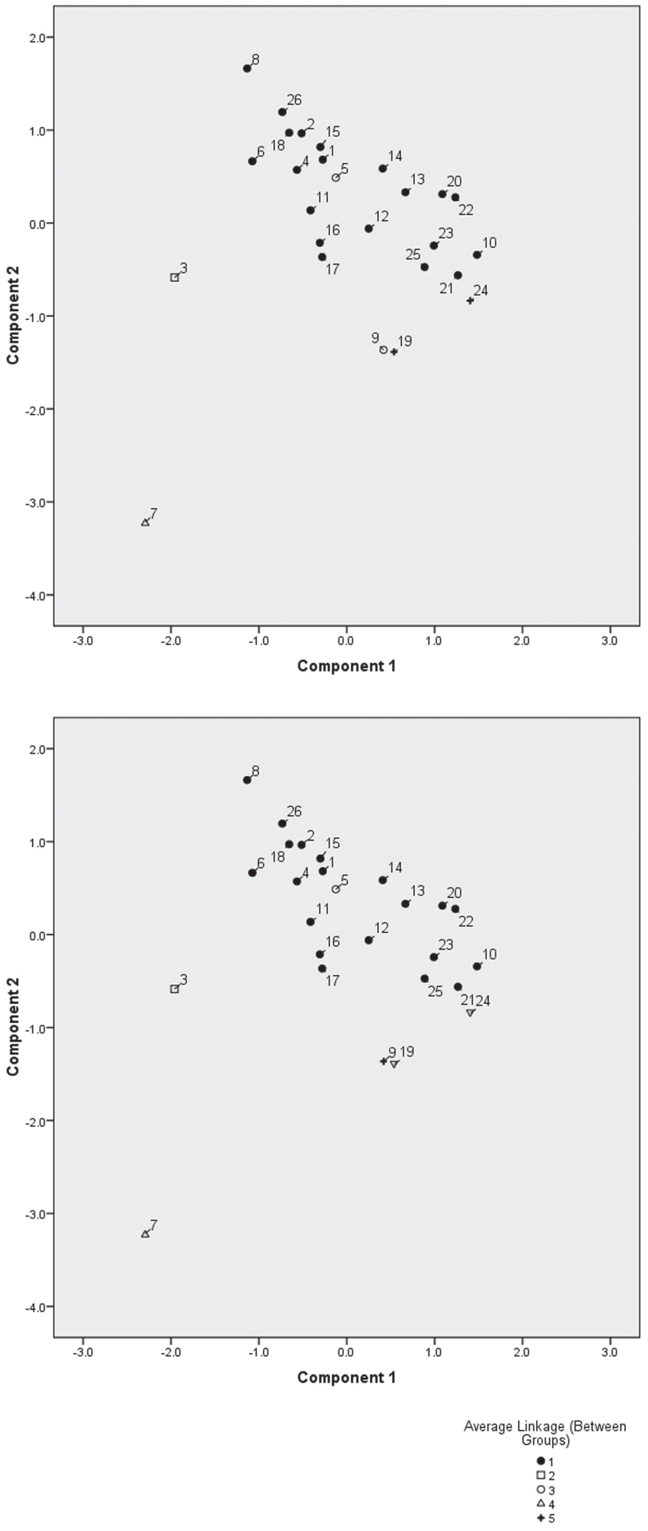

Figure 2.8b. Plots of component one and two from the analysis of the combined data, with handaxes grouped according to the cluster analysis. Top: five clusters; bottom: six clusters.

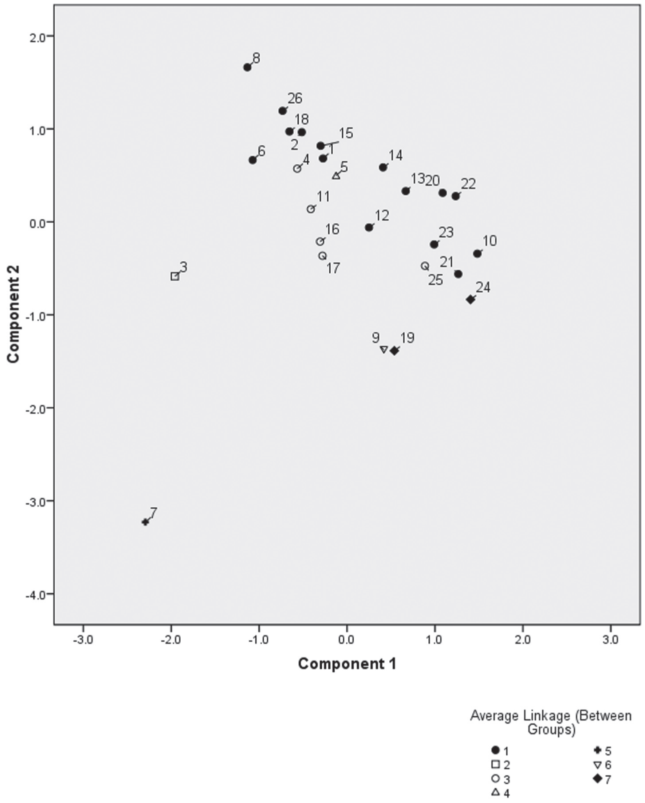

Figure 2.8c. Plot of component one and two from the analysis of the combined data, with handaxes differentiated into seven groups, based on the cluster analysis.

approaching one was extracted, which compares well with the results from the surface data. The results indicate a much lower level of complexity compared to the replica assemblage. The reason for this may be due to the limited restraints placed on the replica assemblage, resulting in greater sources of variation being present, such as raw material choices, knapping strategy selection, and the potential that some may have deliberately changed their approach to provide a range of tool morphologies. In contrast, the hominins at Caddington relied on locally available flint and, as will be discussed further, possibly conformed to socially mediated knapping strategies.

The results were used to produce scatter diagrams, using typological and contextual data to differentiate the handaxes (Figures 2.10 and 2.11). The results from the surface analysis show that clustering of associated surfaces is not prevalent, which is comparable to the replica assemblage. However, there are some instances where this does occur and it is worth noting that two of these are suggested to be the product of the same hand by Bradley and Sampson (1978). While this is possible, there is not enough evidence to support this supposition and the similarities between these handaxes are not as

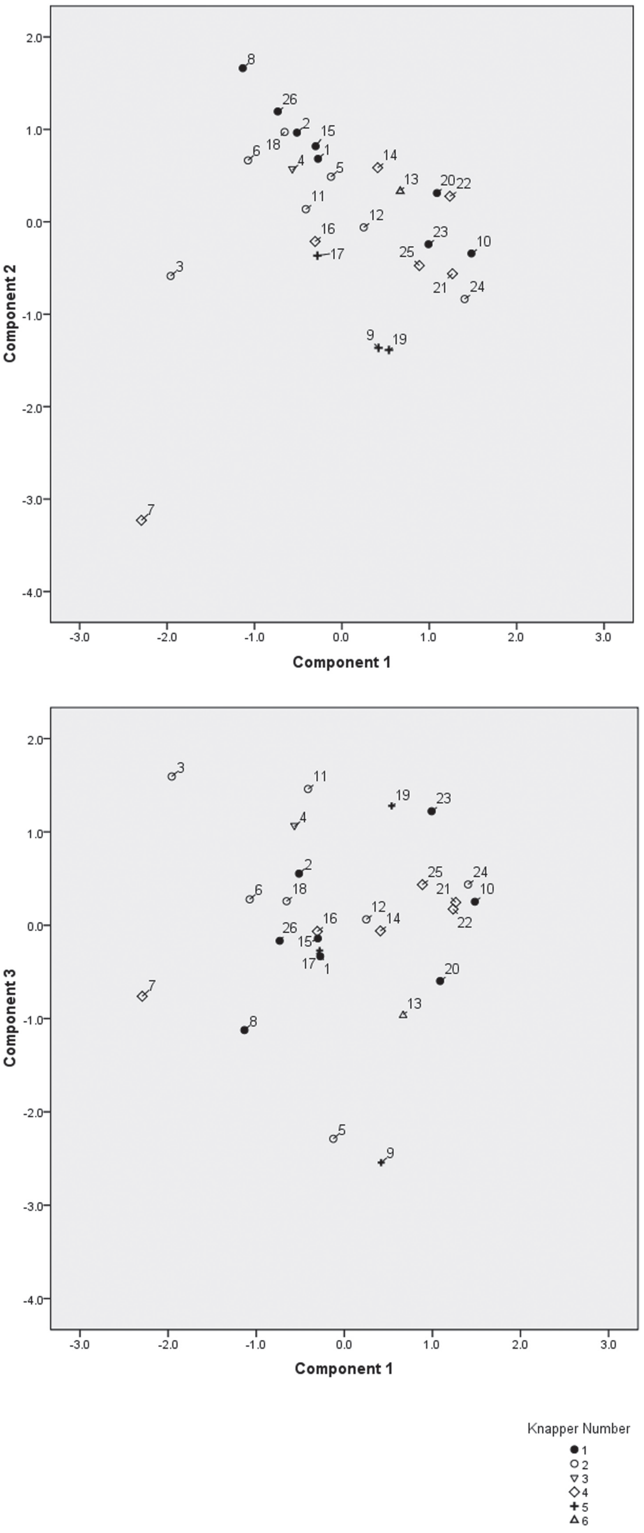

Figure 2.9a. Plots from the analysis of the replica assemblage combined data. Top: component one versus two; bottom: component one versus three. The handaxes are differentiated according to the knappers who made them.

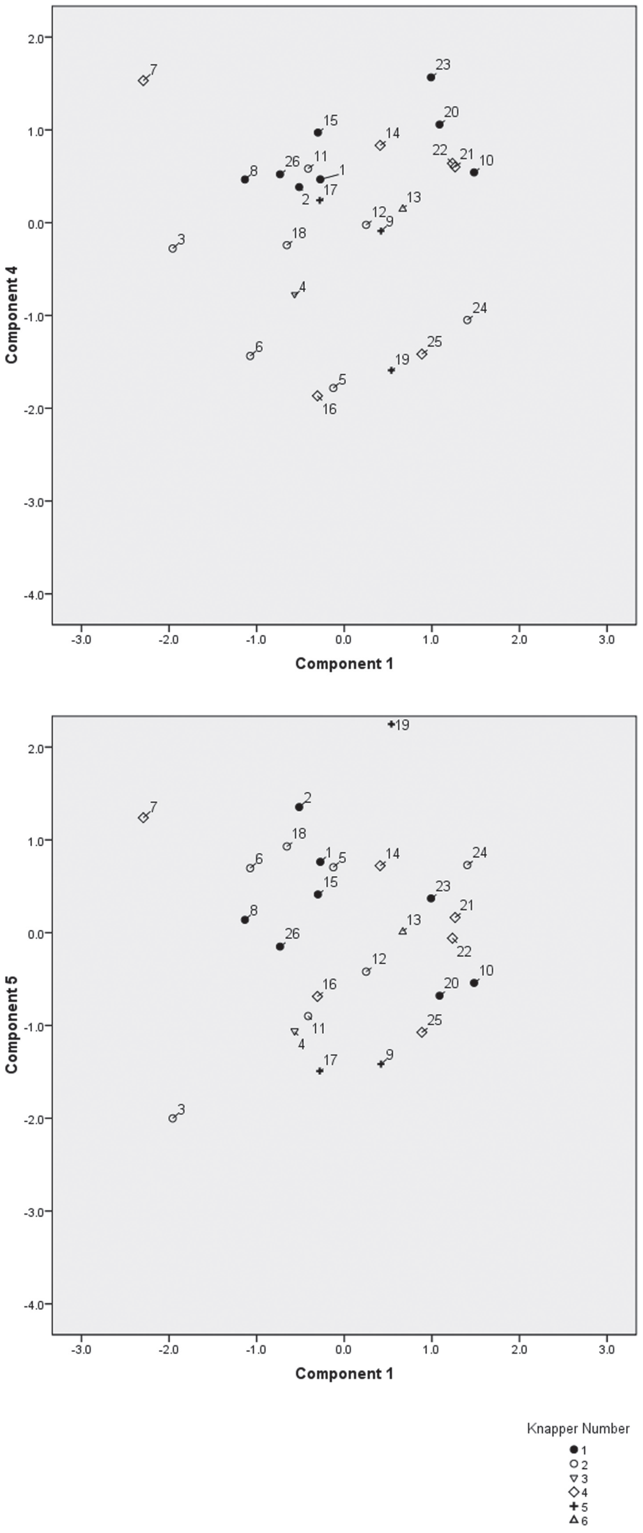

Figure 2.9b. Plots from the analysis of the replica assemblage combined data. Top: component one versus four; bottom: component one versus five. The handaxes are differentiated as per Figure 2.9a.

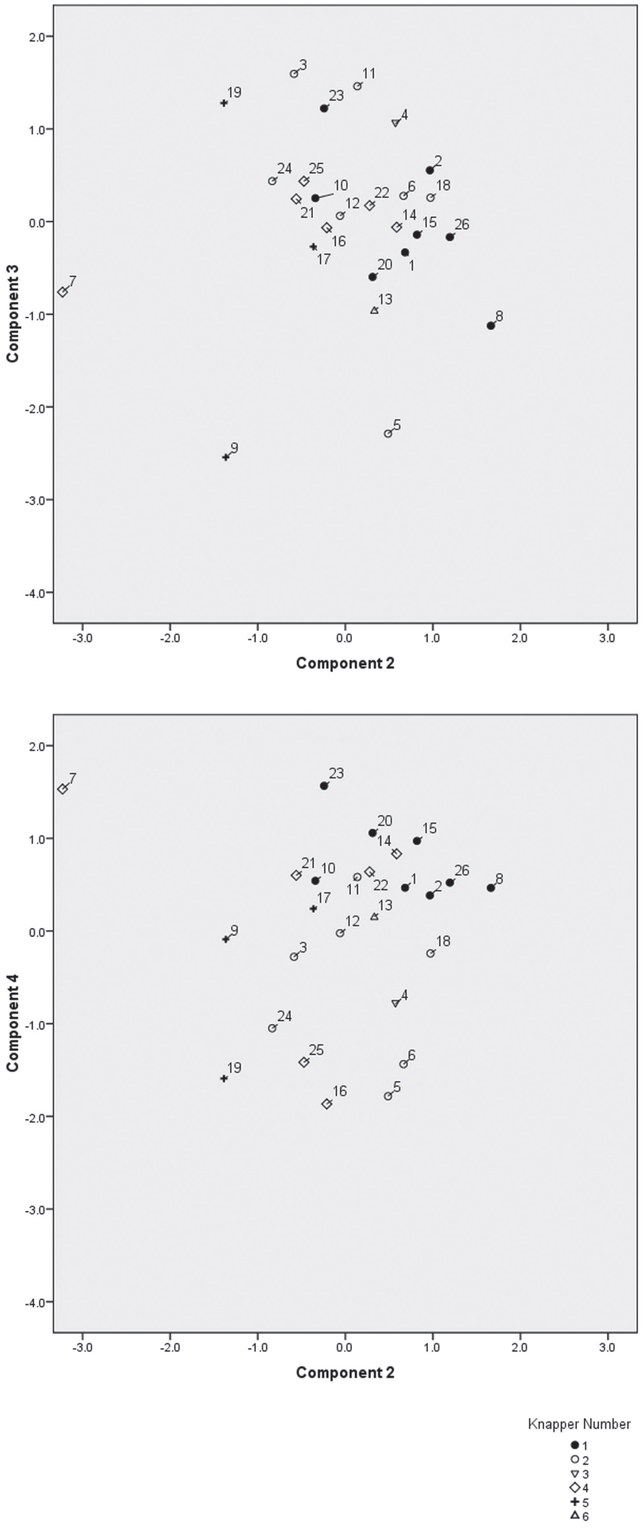

Figure 2.9c. Plots from the analysis of the replica assemblage combined data. Top: component two versus three; bottom: component two versus four. The handaxes are differentiated as per Figure 2.9a.

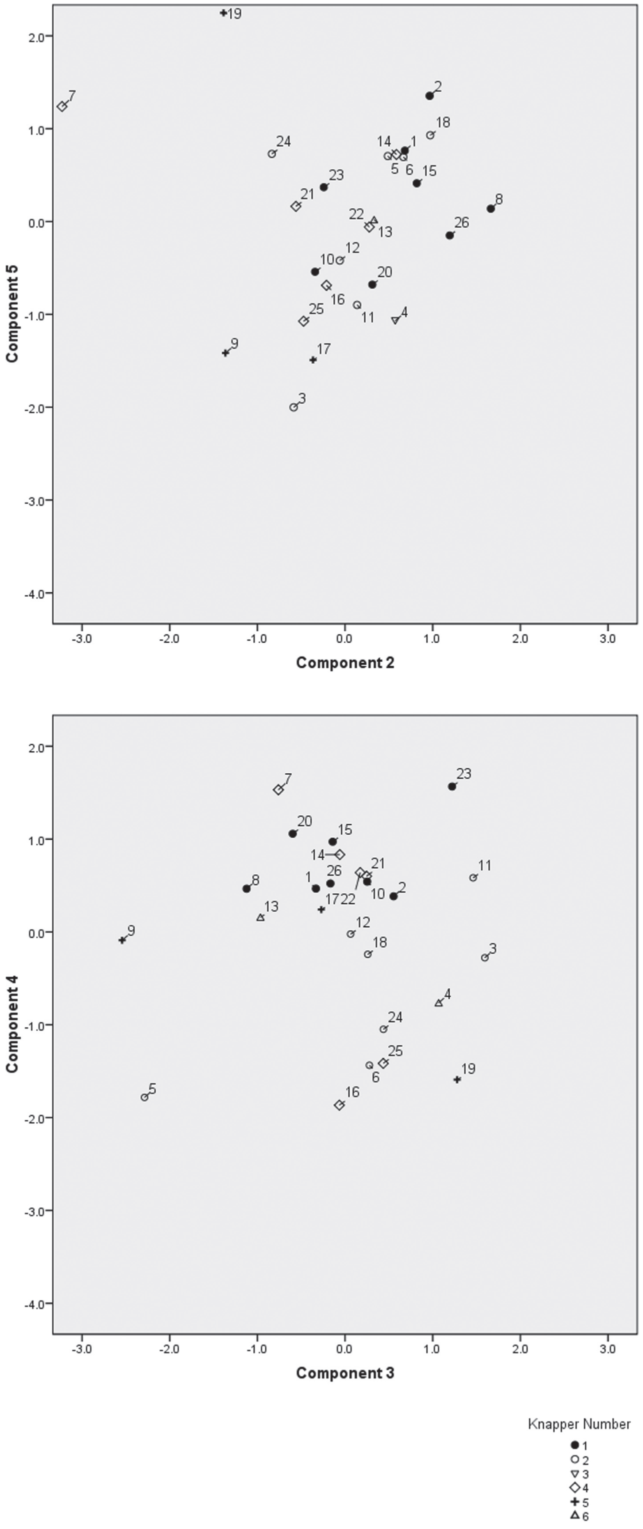

Figure 2.9d. Plots from the analysis of the replica assemblage combined data. Top: component two versus five; bottom: component three versus four. The handaxes are differentiated as per Figure 2.9a.

distinct as other notable handaxe pairs in Britain, such as those from Foxhall Road (White and Plunkett 2004).

The scatter diagrams also display limited separation of the tools according to their shape, although there is some separation according to different pits. Most interesting is the separation of Pit A, C and G handaxes from those attributed to Pits E and F. However, the overlap seen suggests that differences based on find location are not the only explanation for this pattern. Further analysis suggests some degree of separation is dictated by differences in raw material selection, primarily in terms of nodule size. The assemblage displays a range of nodule types, including smaller tabular blanks and rounded pebbles, large tabular nodules, and sub-spheroids. These will almost certainly have affected the choice of reduction strategy (Ashton and McNabb 1994; White 1998a), with smaller nodule size limiting the flaking intensity applied. However, other factors could potentially include differences in skill and contrasts between tools from the Palaeolithic floor and contorted drift.

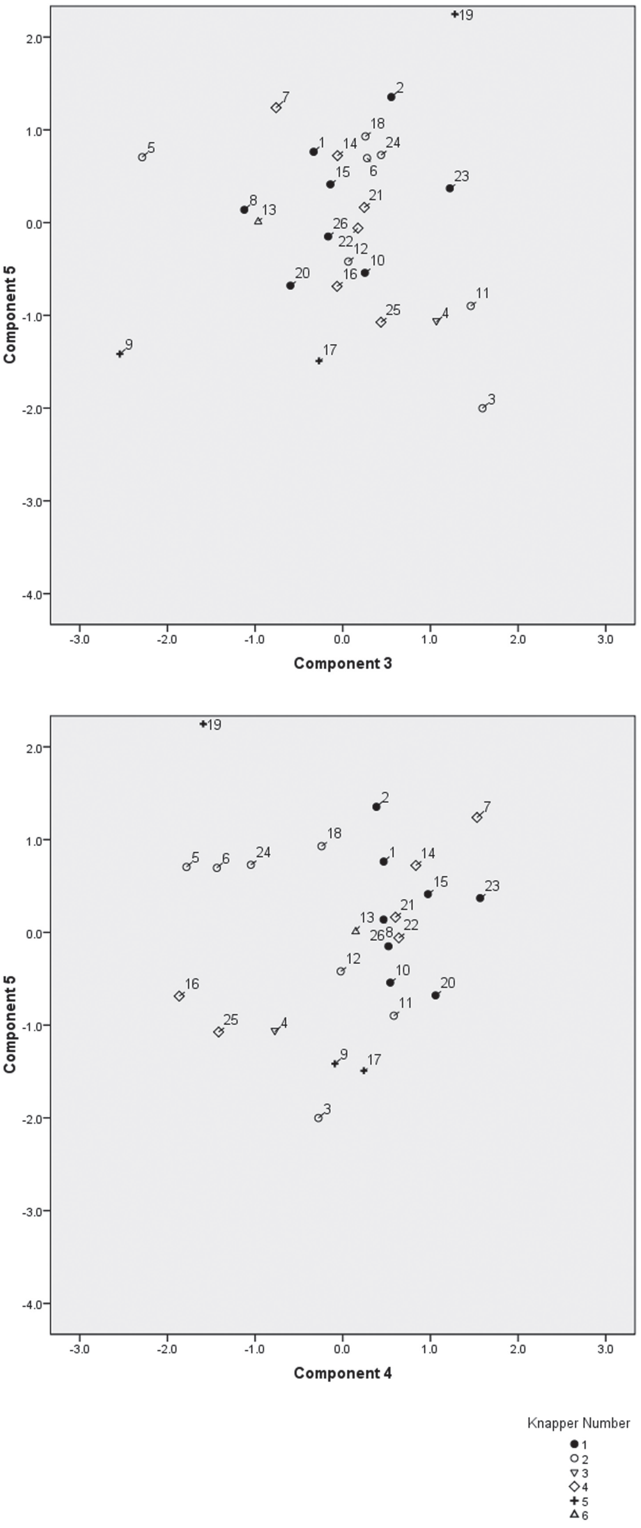

Figure 2.9e. Plots from the analysis of the replica assemblage combined data. Top: component three versus five; bottom: component four versus five. The handaxes are differentiated as per Figure 2.9a.

Discussion

The results presented above clearly demonstrate that Gunn's methodology is unable to correctly differentiate Acheulean handaxes according to their knappers in assemblages where variability extends beyond idiosyncrasies introduced by the individual's hand. Instead, a range of factors force knappers to adopt flexible strategies to lithic reduction. In terms of the replica assemblage, handaxe shape appears to be the primary factor that conditions scar patterning. At Caddington nodule size and variation between the brickearth pits provides a more prominent explanation. The lack of clustering seen between associated handaxe surfaces in both assemblages also demonstrates that both sides of the same tool are often dissimilar. This emphasises the presence of fluidity in the approach to manufacture, thinning and shaping of tools. As a result, knappers modify their strategies in response to a variety of factors to obtain a satisfactory end result, which has clearly resulted in divergent scar patterns. However, some clustering of tools related to specific individuals was noted, such as those produced by Knapper 1. These tend to be similar in size, form and flaking, suggesting that handaxes produced by a single individual that are morphologically similar can be grouped together. This may support Bradley and Sampson's (1978) notion that some of the handaxes from Caddington are related to a single individual, given that these cluster closely in the scatter diagrams, though this cannot be unequivocally proven. This hints that the analysis of individuals within the Palaeolithic may be possible, though only in isolated and limited circumstances.

Total Variance Explained						
Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	32.017	88.937	88.937	32.017	88.937	88.937
2	1.036	2.878	91.815	1.036	2.878	91.815
3	0.678	1.884	93.698			
4	0.355	0.986	94.685			
5	0.181	0.502	95.187			
6	0.161	0.448	95.634			
7	0.141	0.393	96.027			
8	0.129	0.359	96.385			
9	0.109	0.303	96.689			
10	0.099	0.275	96.963			
11	0.092	0.255	97.218			
12	0.087	0.241	97.459			
13	0.075	0.207	97.666			
14	0.074	0.204	97.871			
15	0.071	0.196	98.067			
16	0.065	0.180	98.247			
17	0.062	0.171	98.419			
18	0.059	0.165	98.584			
19	0.054	0.151	98.734			
20	0.047	0.132	98.866			
21	0.045	0.126	98.992			
22	0.040	0.111	99.103			
23	0.038	0.105	99.208			
24	0.034	0.096	99.304			
25	0.032	0.090	99.394			
26	0.031	0.087	99.481			
27	0.027	0.074	99.555			
28	0.026	0.071	99.626			
29	0.025	0.069	99.695			
30	0.024	0.065	99.761			
31	0.018	0.050	99.811			
32	0.017	0.047	99.858			
33	0.015	0.043	99.901			
34	0.014	0.038	99.939			
35	0.013	0.035	99.974			
36	0.010	0.026	100.000			

Table 2.7. Results of the principal component analysis applied to the Caddington assemblage surface data.

The fact that the handaxes from Caddington appear to cluster according to the brickearth pit that they were recovered from that is the most intriguing of all the results. Significant differences in raw material size and type do not seem to be the cause of this, nor does variation in knapping skill. As a result, it is possible that there is a subtle distinction in the way that handaxe manufacture was conducted at Pit E and F, compared to Pits A, C and G. This potentially suggests the presence of different shared, socially mediated templates for the manufacture of handaxes (cf. Pettitt and White 2012; White in press). It also highlights that the brickearth pits may not be contemporaneous, as Smith (1894) originally suggested. Sampson (1978b) has already expounded on this, noting that the horizons containing artefacts formed in isolated solution hollows within the chalk.

		Component Matrix	
		Component	
		1	*2*
Horizontal	V1	0.872	0.357
	V2	0.894	0.360
Right Horizontal	V3	0.919	0.276
	V4	0.936	0.223
	V5	0.934	0.163
	V6	0.940	0.087
	V7	0.957	-0.043
	V8	0.951	-0.074
Right Centre	V9	0.955	-0.076
	V10	0.948	-0.127
	V11	0.953	-0.163
	V12	0.955	-0.179
	V13	0.949	-0.171
	V14	0.963	-0.157
Vertical	V15	0.961	-0.101
	V16	0.955	-0.032
	V17	0.944	0.064
	V18	0.931	0.117
	V19	0.898	0.204
	V20	0.917	0.213
	V21	0.946	0.111
	V22	0.965	0.072
Left Centre	V23	0.961	-0.032
	V24	0.962	-0.115
	V25	0.953	-0.193
	V26	0.955	-0.198
	V27	0.959	-0.184
	V28	0.957	-0.196
Left Horizontal	V29	0.949	-0.208
	V30	0.942	-0.155
	V31	0.949	-0.162
	V32	0.947	-0.074
	V33	0.947	0.033
	V34	0.952	0.088
Horizontal	V35	0.933	0.164
	V36	0.931	0.212

Table 2.8. The component matrix from the analysis of the Caddington assemblage surface data, displaying loadings for both extracted components.

Therefore, a chronological element may be present which could account for the clustering seen. This is certainly important to consider, given the difficulties in providing an accurate date to the Caddington material (Campbell and Hubbard 1978; Catt *et al.* 1978; McNabb 2007; White 1997). Interpretation is further complicated due to the mixture of *in situ* artefacts from the Palaeolithic floor with derived material within the contorted drift. As a result, the separation according to brickearth pits could be argued to result from temporal or cultural factors, or both. However, this does not deny that hominins at Pit E and F appear to have worked flint in subtly different ways. As a result, it can be emphatically stated that the artefacts from Caddington can no longer be treated as a *whole* and must be considered as *separate* assemblages.

The suggestion that differences in socially mediated knapping strategies can be detected stands in contrast to the seemingly continuous variation seen at the inter-site level within the Acheulean. It is suggested that, given limited differences in the flint available between the Caddington brickearth pits, the differences in scar patterning seen, and by extension the method of reduction used, may have been detected due to the fact that hominins were utilising relatively similar raw material sources. Therefore, while group templates may be present, time averaging and the properties of the flint selected for reduction tend to conceal them. In other words, this appears to be Isaac's (1972) random drift model writ large.

This has immediate resonance for the study of the hominin individual. It appears that any method of reduction that has been socially defined is only detectable at sites that have been extensively used by different groups of hominins with access to similar raw material sources. At the inter-site level, flexible mental templates were constantly being redefined by differences in locally available raw material. This forced hominins to adapt any predefined knapping strategy in order to achieve their goals. Thus, we would expect to see regular drift within reduction modes due to the suggested mobility of hominins as they traversed between nodal points within their localised landscapes of habitat (Gamble 1999), as well as the general passage of time. Such an interpretation has strong implications for how we view local variability and the wider patterning in the Acheulean.

In terms of the British record, White (1998a, b) has noticed characteristics within handaxe manufacture that cannot be explained by extra-somatic factors and may be linked to cultural variation. Some of these may be due to the Palaeolithic settlement of Britain, which is represented by colonisation and extirpation events that correspond to the presence/absence of the land bridge that links to the rest of Europe (Ashton and

Total Variance Explained						
Component	***Initial Eigenvalues***			***Extraction Sums of Squared Loadings***		
	Total	*% of Variance*	*Cumulative %*	*Total*	*% of Variance*	*Cumulative %*
1	33.348	92.635	92.635	33.348	92.635	92.635
2	0.952	2.644	95.279	0.952	2.644	95.279
3	0.474	1.316	96.594			
4	0.192	0.535	97.129			
5	0.131	0.365	97.494			
6	0.116	0.321	97.815			
7	0.088	0.246	98.060			
8	0.079	0.219	98.279			
9	0.064	0.177	98.457			
10	0.062	0.171	98.628			
11	0.053	0.148	98.776			
12	0.049	0.136	98.912			
13	0.045	0.124	99.036			
14	0.042	0.117	99.154			
15	0.036	0.101	99.254			
16	0.034	0.095	99.349			
17	0.030	0.084	99.432			
18	0.027	0.074	99.507			
19	0.024	0.067	99.574			
20	0.022	0.061	99.635			
21	0.020	0.055	99.690			
22	0.019	0.052	99.742			
23	0.014	0.039	99.781			
24	0.012	0.034	99.816			
25	0.012	0.034	99.849			
26	0.010	0.028	99.877			
27	0.008	0.022	99.899			
28	0.007	0.020	99.919			
29	0.006	0.017	99.936			
30	0.006	0.015	99.952			
31	0.005	0.013	99.964			
32	0.004	0.011	99.975			
33	0.004	0.010	99.985			
34	0.002	0.007	99.991			
35	0.002	0.005	99.996			
36	0.001	0.004	100.000			

Table 2.9. Results of the principal component analysis applied to the Caddington assemblage combined data.

Lewis 2002; Pettitt and White 2012; White and Schreve 2000). Given that Britain is therefore a population sink, characteristics linked to potential cultural variation may have been introduced by colonising groups, as well as spread through inter-group networks and localised operational areas (Pettitt and White 2012; White and Pettitt 2011). A primary example is found in the twisted ovate phenomenon (White 1998b), attributed to MIS 11/10, which displays temporal clustering of artefacts, despite limited evidence of spatial clustering (White and Schreve 2000). It is possible that this technique was common amongst early colonisers and insularity helped sustain this technique, though earlier assemblages from Swanscombe and Hoxne where twisted forms are rare argues against this. It is also possible that the twisted form was an underused variant, which then proliferated with the isolation of Britain from the continental mainland.

White also sees further patterning that may be due to the nature in which Britain was colonised (Pettitt and White 2012; White pers. comm.). Using Roe's (1968) handaxes groups, which initially display no evidence of patterning based on broad differences between pointed and ovate forms, finer scale variation within the sub-groups can be linked to chronological patterns based on date ranges from sites with recent age correlations from biostratigraphic, lithostratigraphic and absolute dating. If White is correct and this patterning is real, then this may be a step towards explaining why strong traditions appear within intra-regional studies of the British record (*e.g.* Mithen 1994), as opposed to elsewhere. However, the apparent conservatism within the Acheulean suggests that this industry involved strong rules, with variation amounting to constant changes to an overarching formula governed by social guidelines. Individuals may have been able to express themselves through tool manufacture, inserting the variability that is present within the archaeological record, but did not have the capacity to invoke lasting change to the parameters that governed the techniques used (Hopkinson and White 2005).

The evidence from the analysis presented here would seem to support this view, with the added caveat that such variation may stem from changes in group structure. This would also be a potential explanation for the presence of local variations, such as the twisted ovate (White 1998b; White and Schreve 2000). On a wider scale, the phylogenetic drift seen within the global patterning of the Acheulean (Lycett 2009) may also be linked to concepts of group movements and the social transmission of learned behaviour. However, utilisation of localised resources, proved by raw material studies, suggests hominins had to overcome raw material constraints relative to the locally available resources in order to meet a set of required needs. In addition, it is possible that the limited range of options available to hominins, combined with the requirement to meet specific needs, would have limited the range of forms that could be selected from, thus restricting the development of individual or group styles. As Nowell and White (2010) have postulated, the locality of social life and low group membership within the Lower Palaeolithic would have limited the wide ranging transmission of innovations, thus leading to isolated and short lived instances of highly variable behaviour being transmitted, probably learnt through a many-to-one process (Lycett and Gowlett 2008), which subsequently vanished as groups became extinct.

Overall, therefore, we do not see different socially mediated modes of reduction, but rather detect contrasts in the materials that were utilised at localised nodal

	Component Matrix		
		Component	
		1	*2*
Horizontal	V1	0.904	0.340
	V2	0.925	0.319
Right Horizontal	V3	0.943	0.234
	V4	0.958	0.213
	V5	0.957	0.147
	V6	0.967	0.077
	V7	0.974	-0.042
	V8	0.969	-0.090
Right Centre	V9	0.973	-0.061
	V10	0.969	-0.121
	V11	0.968	-0.151
	V12	0.966	-0.182
	V13	0.964	-0.168
	V14	0.974	-0.159
Vertical	V15	0.972	-0.103
	V16	0.974	-0.040
	V17	0.963	0.082
	V18	0.952	0.144
	V19	0.929	0.219
	V20	0.940	0.226
	V21	0.963	0.143
	V22	0.977	0.082
Left Centre	V23	0.980	-0.018
	V24	0.979	-0.101
	V25	0.971	-0.173
	V26	0.966	-0.197
	V27	0.974	-0.178
	V28	0.969	-0.177
Left Horizontal	V29	0.965	-0.201
	V30	0.966	-0.158
	V31	0.967	-0.160
	V32	0.961	-0.094
	V33	0.969	0.019
	V34	0.972	0.071
Horizontal	V35	0.964	0.130
	V36	0.958	0.196

Table 2.10. The component matrix from the analysis of the Caddington assemblage combined data, displaying loadings for both extracted components.

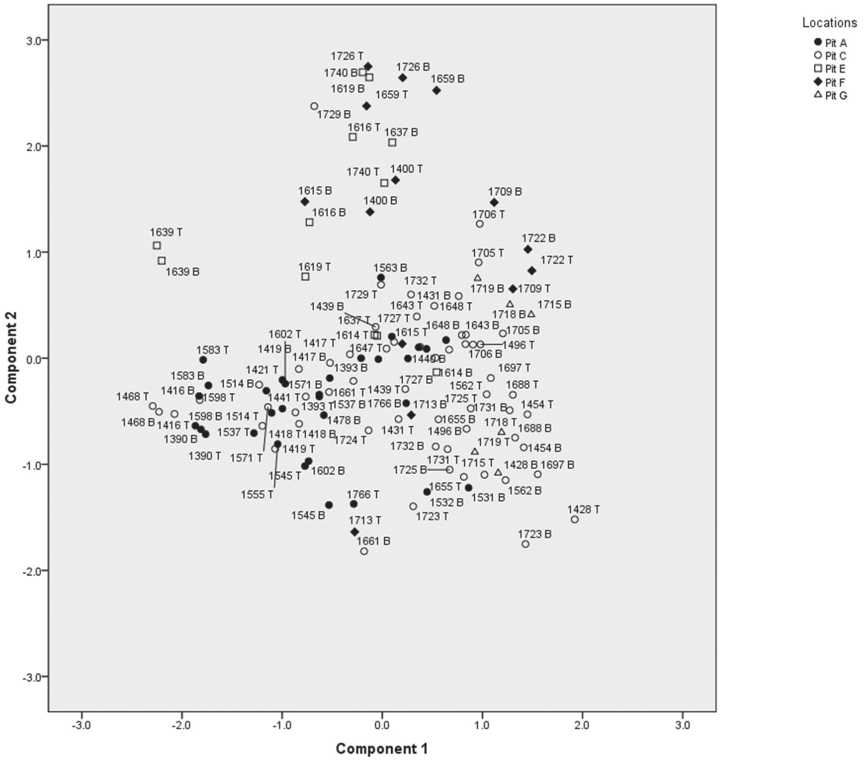

Figure 2.10. Plot of component one and two from the analysis of the Caddington assemblage surface data. The handaxes are differentiated according to which pit they originated from.

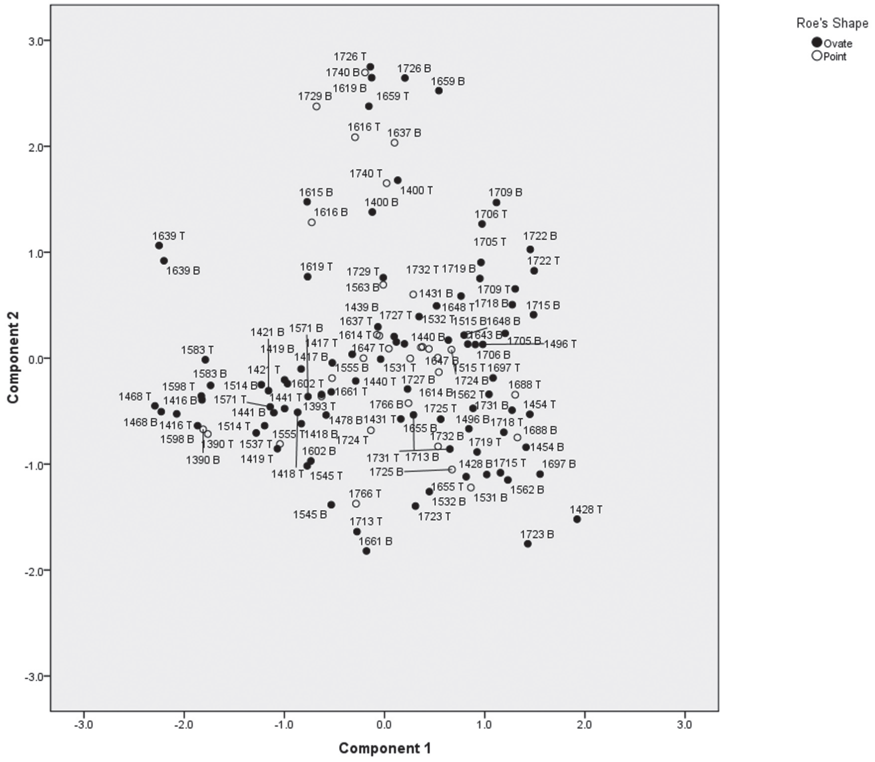

Figure 2.11. Plot of component one and two from the analysis of the Caddington assemblage surface data. The handaxes are differentiated by shape, based on Roe's (1968) typology.

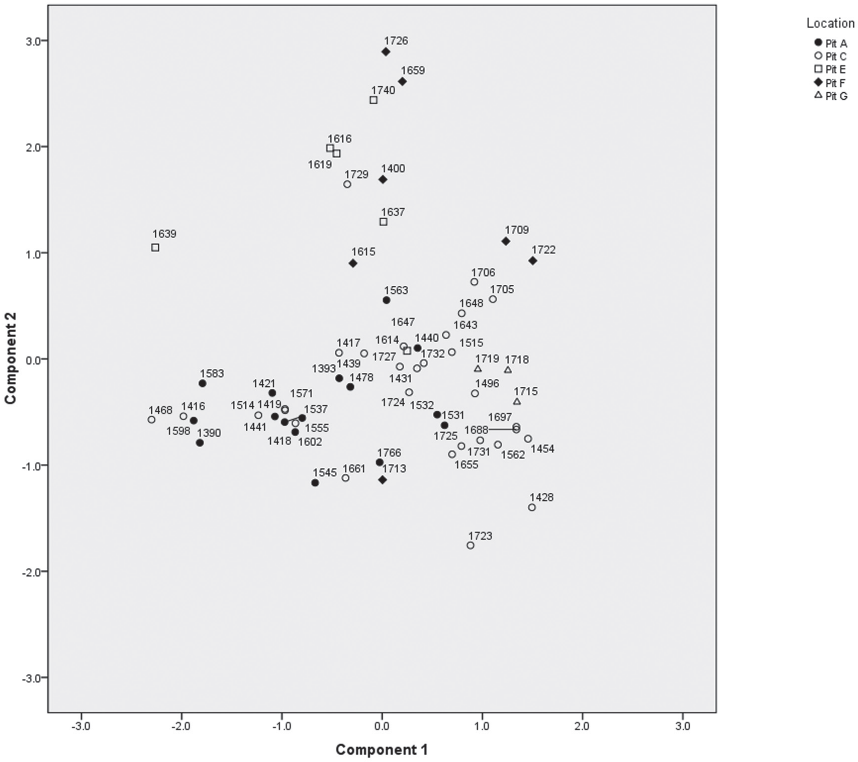

Figure 2.12. Plot of component one and two from the analysis of the Caddington assemblage combined data. The handaxes are differentiated according to which pit they originated from.

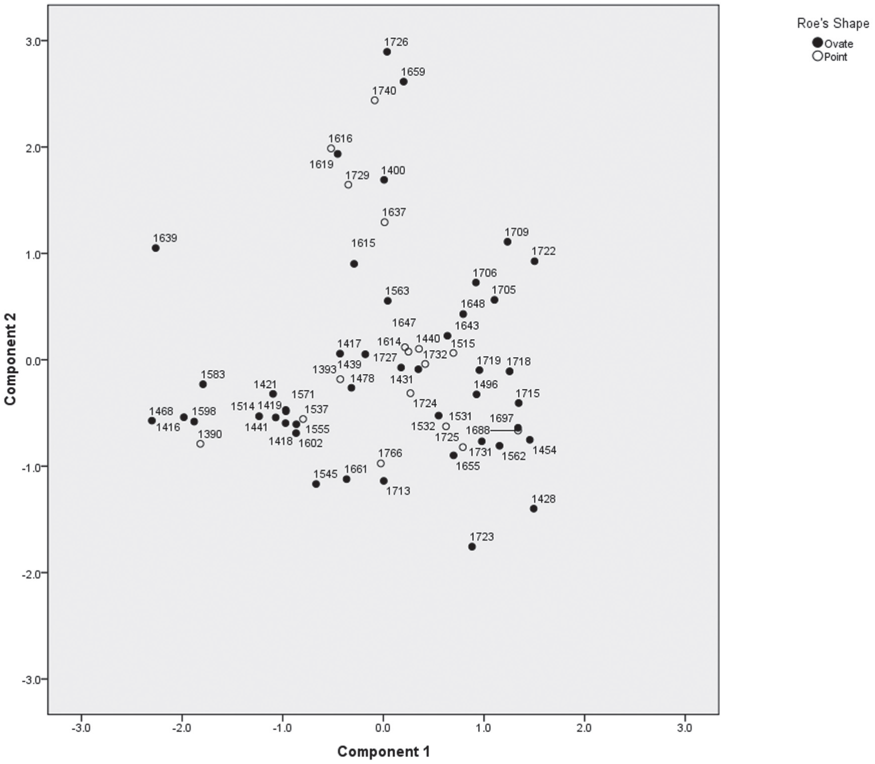

Figure 2.13. Plot of component one and two from the analysis of the Caddington assemblage combined data, with handaxes differentiated by shape, based on Roe's (1968) typology.

points within short ranging landscapes of habit. Subsumed within this are individuals themselves, whose actions appear to be guided by society, but must mitigate the limitations of raw material in the manufacture of a useable end product. Therefore, the variability of the Acheulean is considered to be the result of individual action, which is mediated by society and adapted to the nature of the lithic material chosen for reduction. In many ways, we can draw parallels between these concepts and the social behaviour seen in our societies today. However, as McNabb (2007) notes, we cannot conceive of Lower Palaeolithic hominins being the same as us. While it is tempting to try and compare modern social behaviour to that of *Homo heidelburgensis,* it is important not to fall readily into this trap. As yet, it appears that the interplay between the factors that were instrumental in determining hominin behaviour are not fully understood. If our goal is to produce a meaningful analysis that is orientated from the bottom up, then further work is needed to tease these elements apart in the hope that they can be better understood.

Conclusions

This paper has attempted to trace individuals via the analysis of flake scar patterning, using a methodology based on Gunn's (1975) experiments. The results of this analysis have shown that the handaxes under study do not cluster according to the individual who created then, contra to what Gunn originally claimed. This emphasises a bias in Gunn's original sample of bifaces, which was controlled in such a way as to maximise the individual's contribution to the variance. Instead, it is the size of the raw material and shape of the finished tool that appear to influence any patterning in flake scars. However, clustering of handaxes from the Acheulean site of Caddington displays separation of the archaeological material based on the brickearth pits it was recovered from. This suggests that some of the variance can potentially be explained by differences in the approach to reduction used by hominins at these pits, though the lack of strong chronological constraints and the issues of separating the material from the Palaeolithic floor and contorted drift prevent the author from determining whether changes to the scar patterning result from contemporary or temporally displaced groups. Given the chronological patterning suggested by White (in press), it is more likely that the latter of these is correct. This then emphasises the fact that artefacts from Caddington are *not* a single assemblage and should not be treated as such. Instead, they present a series of potentially chronologically displaced exploitation events around solution holes formed within the local chalk bedrock, during which hominins manufactured tools guided by their desires and the limitations of the raw materials, as well as some form of socially mediated or learnt tradition.

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Note

1. Here it should be noted that references to the individual made within the text refer not to the Western concept of a bounded self. Instead this is a reference to an individual agent within a wider society founded on the social relationships that they both create and maintain, irrespective of how they conceived of themselves.

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3. Alpine 'Hunters' from the Middle Mesolithic to Early Neolithic: A contribution to the study of lithic industries from two high altitude loci (Gerland and La Mare) in Vercors, Northern French Alps

Alexandre Angelin

Introduction

The Mesolithic was a very significant period in terms of environmental changes, in addition to complimentary adaptions of human subsistence strategies. Not only did this period see radical climatic shifts, its conclusion, the beginning of the Neolithic, saw the transition between the last hunter-gatherers and the first 'farmers'. Although this essential phenomenon of 'Neolithisation' has begun to be unraveled in some European regions, its dynamics and origins in the alpine mountain range are poorly understood.

Situated in the western French Alps, in the French departments of Isère and Drôme, the pre-alpine mountain range of Vercors (Figure 3.1) has been the focus of archaeological exploration for a long time. With an average altitude ranging between 1000 and 1600 m above mean sea level (AMSL), and culminating at 2341 m AMSL at the Grand Veymont, Vercors is particularly well known for its alpine plateau (commonly known as 'Hauts-Plateaux'). Covered by a varied landscape of grasslands, forests, and cliffs, the numerous mountain passes have been occupied repeatedly since the end of the Late Glacial in Europe (Bintz *et al*. 2008).

The occupation of Vercors has been known since the end of the nineteenth century. Large breakthroughs in our knowledge of the prehistory of the Alps have been made thanks to the work of pioneers such as Hippolyte Müller, who worked in Vercors for nearly 50 years. Until the 1970s, archaeologists mostly focused their research on rockshelters at low and mid-altitudes. For the past three decades, however, the focus has changed and surveys and test excavations have been carried out with great enthusiasm at altitudes above 1500 m AMSL in various pre-alpine mountain ranges, such as Chartreuse, Dévoluy and Vercors (Bintz *et al.* 1991; Bintz and Argant 1999; Bintz and Picavet 1992; Picavet *et al*. forthcoming). As one of the few areas where Alpine research has been most active over the past decades, Vercors stands out as one of the key areas for understanding the important issues surrounding the Neolithisation of the Alps.

The aim of this paper is to present and discuss the results obtained from techno-typological analysis carried out on middle Mesolithic and early Neolithic lithic assemblages. Two open-air loci at high altitudes in the plateau of Vercors were chosen for this purpose: Gerland and La Mare. Very few studies of this nature have been undertaken in this region, and the majority remains unpublished, which limits the amount of accessible data on the subject. Following a rigorous observation and analysis of each assemblage, a chrono-cultural interpretation will be proposed, which includes comparisons with other settlements in the Vercors area (see for instance: La Grande Rivoire and Pas de la Charmate) as well as at the larger scale of the Alps and surrounding zones. Each site will then be placed within the chrono-cultural sequence derived from Vercors.

Areas of study *(Figure 3.1)*

The Plateau of Gerland (1530 m AMSL)

The prehistoric site of Gerland is located on a little slope surrounded by crops. A perennial spring, located approximately 200 m from the site, makes the area well adapted for prehistoric occupation. Discovered by Picavet and Bernard-Guelle in 1998, test excavations at the site took place the following year (Picavet and Bernard-Guelle 1999).

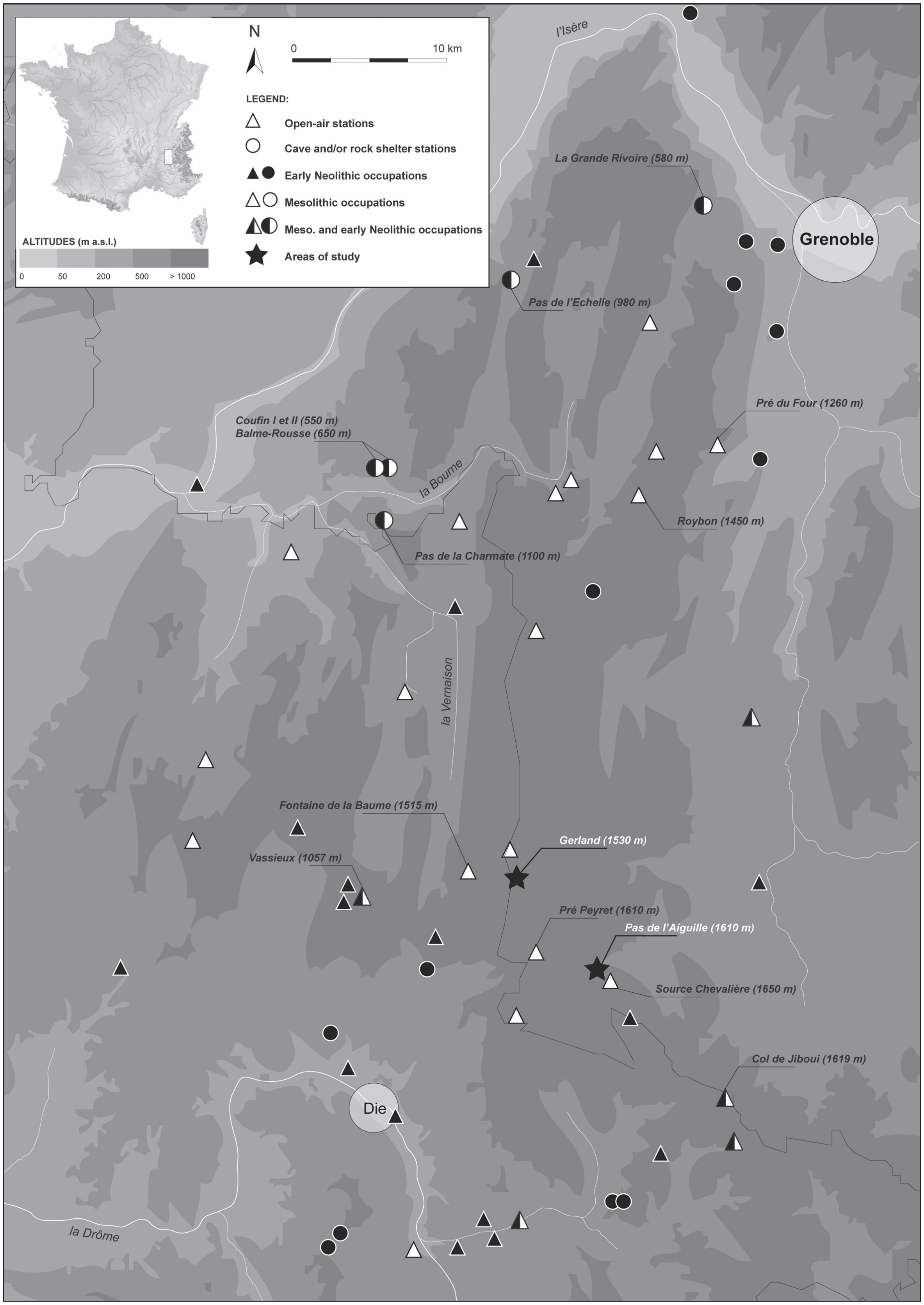


Figure 3.1. Map of the range of Vercors including the distribution of the main Mesolithic and early Neolithic settlements. Cartography: P Tallet (Paleotime). CAD: A. Angelin.

Blank details		**Code**
First blades (from unprepared core)		A1a
Cortical blades		A1b
Maintenance blades		A2a
	Lateral blades (right)	A2b
	Lateral blades (left)	A2b'
Blades of *plein débitage*		
	Triangular section (rythm 1-2/2-1)	B1
	More than three scars	B2
	Trapezoidal section (rythm 2-1-2')	C1
	Trapezoidal section (rythm 1-2-3/3-2-1)	C2
	Undetermined trapezoidal section	C'
Undetermined blades		D

Table 3.1. Codes and description of laminar blanks, after Binder (1987, 1991) and Perrin (2003a) (modified).

Gerland: Blank types		**N**	**%**
Entire flakes		95	15.9%
	Proximal fragments	82	13.7%
	Other fragments	135	22.6%
Entire blades		6	1.0%
	Proximal fragments	69	11.5%
	Mesial fragments	150	25.1%
	Distal fragments	49	8.2%
Blade cores		4	0.7%
Flake cores		2	0.3%
Undetermined cores		2	0.3%
Quartz		4	0.7%
Sub-total		**598**	**100.0%**
Undetermined		*90*	
Splinters		*483*	
Debris		*740*	
Total		**1911**	

Table 3.2. Composition of the lithic assemblage at Gerland.

La Mare in Pas de l'Aiguille (1610 m AMSL)

This settlement is part of a very complex set of loci that together form the archaeological site of Pas de l'Aiguille. La Mare owes its name to a basin dug by mountain farmers during the eighteenth and nineteenth century for watering bovids and horses. In 2005, Picavet and Morin (2005) conducted a research project on pastoralism followed by some archaeological test excavations.

Study Methods

The taphonomy of open air sites in Vercors

In open-air contexts of the Alps, the lack of stratigraphic sequences often renders assemblages culturally and temporally heterogeneous. Several millennia of human occupation (from the early Holocene to the Medieval period) have often been documented in the same stratigraphic unit, demonstrating a palimpsest of significant temporal proportion. To move beyond this impasse, a technologically focused analysis drawing heavily upon pre-existing Mesolithic and early Neolithic arrowhead typologies, has allowed us to reconstruct chronological associated *chaînes opératoires* and re-contextualise the place of these site in the Neolithisation of the Alps.

Analytical tools

Raw material analysis

The condition of the material differs from Gerland to La Mare. Whereas the Gerland lithics display a very strong patina, with more than 50% of the specimens being burned and, in some cases, fractured by heat, La Mare has incredibly well preserved lithic material.

The study of the raw material economy can provide a great deal of information regarding prehistoric supply strategies. Although some work has already been done in this area (see Bressy 2003), preliminary petrographic observations by P. Fernandès (Paleotime, France) are in the process of being published (Angelin *et al.* forthcoming).

A few words on the analysis of knapped stone

For techno-typological analysis, although basic concepts remain the same, adaptations must be made for each assemblage. Thus, the taphonomy of the settlements and the lithic assemblages conditioned the methodological approach for this study.

The typology for the cores is based on the work of Perrin (2001, 30), and uses codes for the different types of blades and bladelets after Binder (1987; 1991) and Perrin (2001) with a slight modification to suit our needs (Table 3.1). Moreover, the technological methods of analysis used (Binder 1987, modified by Perrin 2001) allowed us to consider a range of criteria, such as blank type and shaping technique.

Analysis of the lithic industry at Gerland

Assemblage

A total of 1911 pieces of flaked flint were found at Gerland (Table 3.2). Abundant splinters (n=483), thermally affected debris (n=740), and cores (n=8) constitute good evidence for *in situ* knapping activities and enable every step of the *chaîne opératoire* to be described.

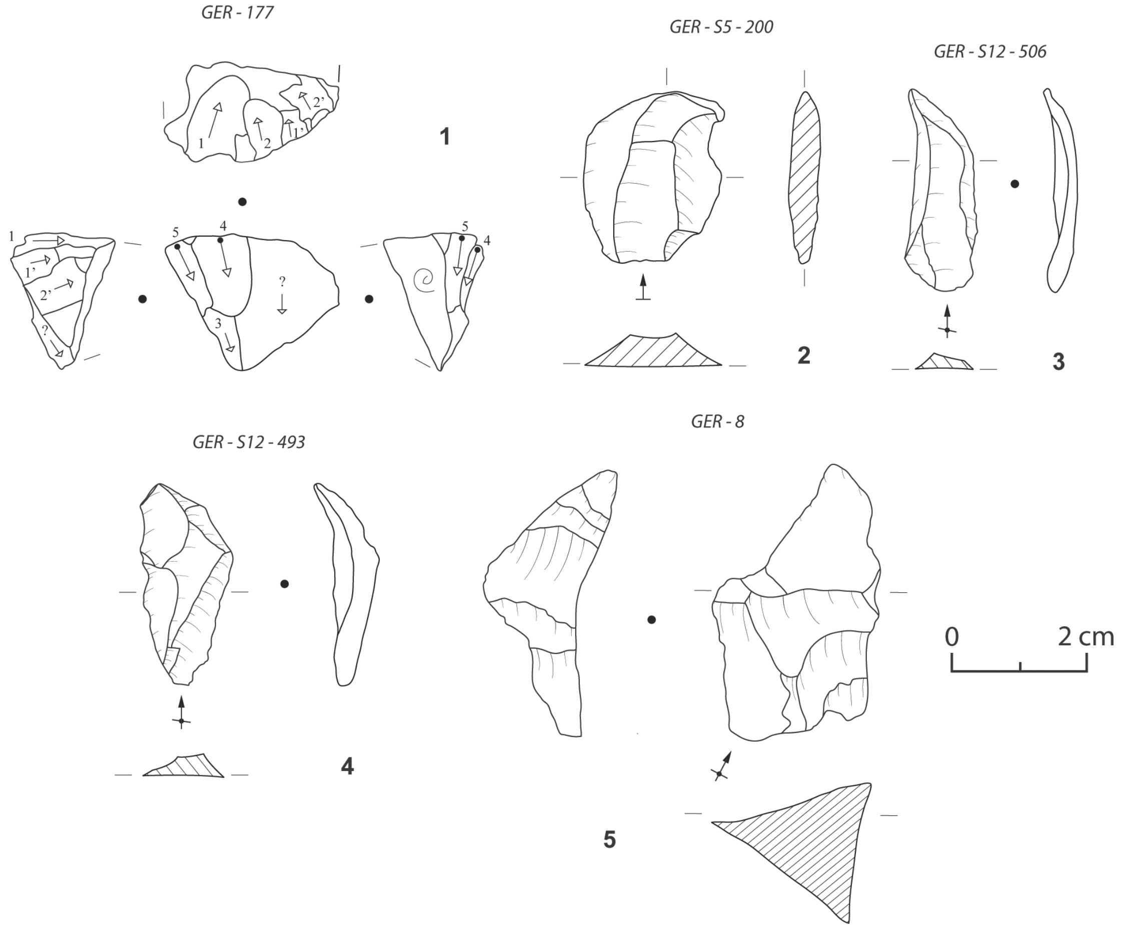


Figure 3.2. The Middle Mesolithic lithic industry from Gerland: 1. bladelet core fragment; 2–5. maintenance flakes. CAD: A. Angelin.

Techno-typology

Cores

Blade and bladelet cores, while representing a small proportion of the total lithic assemblage, are technologically informative. Three bladelet cores were prepared for the production of small and short bladelets. The width and length of these cores are rather narrow (less than 30 mm wide and around 25 mm long; see Figure 3.2, no. 1). Judging from the nature of the cortical surfaces remaining on these cores, we can thus conceive the original size, and relatively unproductive quality of these artifacts before production as being around 35 mm wide and 45 mm long. The shaping of the nodules and the opening of the striking platform seem to have been done by the removal of simple flakes. Bladelets are produced from a single striking platform, and removals from the flaking surface, or the 'rhythm of *débitage*', follow a semi-circular or circular pattern according to the morphology of the core. The result is cores that resemble pyramidal cores with a circular striking platform when the rhythm is circular, and pyramidal cores with a cortical 'back' on semi-circular cores. The goal was the creation of small bladelets with a width of 5–6 mm by direct percussion with a soft-stone percussor. The striking platform is often prepared by abrasion and two distinctive methods of maintenance have been observed. The first involves the removal of plunging flakes to correct mistakes on the flaking surface of the core (generally one or several hinged removals; Figure 3.2, no. 2). The second concerns the removal of flakes and twisted bladelets from the area of intersection between the flanks and the flaking surface of the core. These removals maintain the required convexities of flaking surfaces that allow for continued bladelet production – the longitudinal convexity/curvature, or '*caréne*', and the transverse convexity/curvature, or '*cintre*'. Although not directly

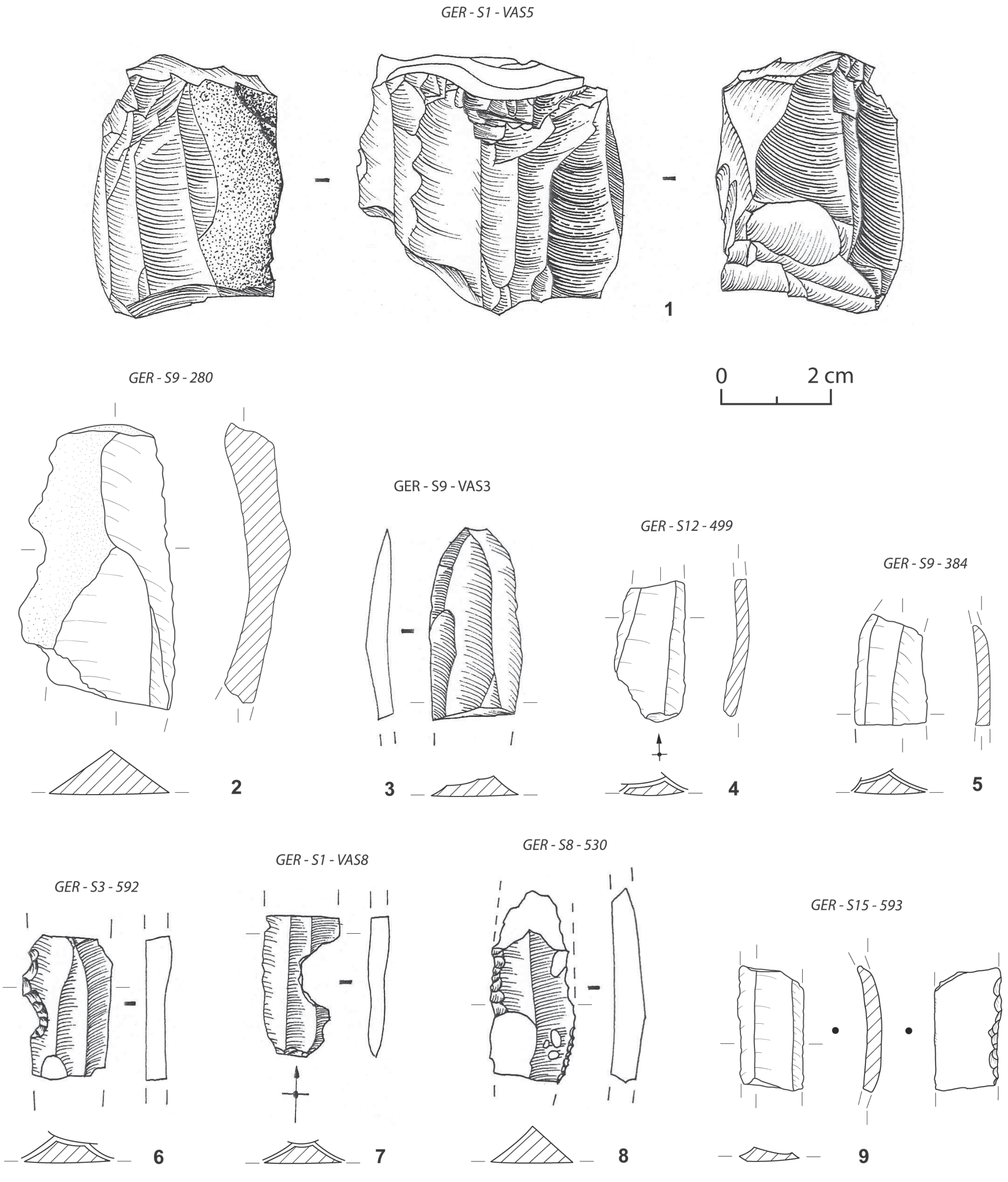


Figure 3.3. The Early Neolithic lithic industry from Gerland: 1. blade core; 2. shaping blade (A1 type); 3–5. raw blades of plein débitage; 6–9. irregular side removals on blades. Drawings 1, 3 and 6–8 by R. Picavet. CAD: A. Angelin.

related to a maintenance process, a few flakes (Figure 3.2, no. 5) show a clear shift in the orientation of *débitage* using one of the flanks as a new striking platform. The angle formed by the previous striking platform and *débitage* surface is then used as a guiding 'crest'.

Only one core was doubtlessly used for the production of large blades using a unique striking platform (Figure 3.3, no. 1). It was possibly shaped by the removal of large cortical flakes (Figure 3.3, no. 2) and the preparation of a postero-lateral crest. The main intention appears

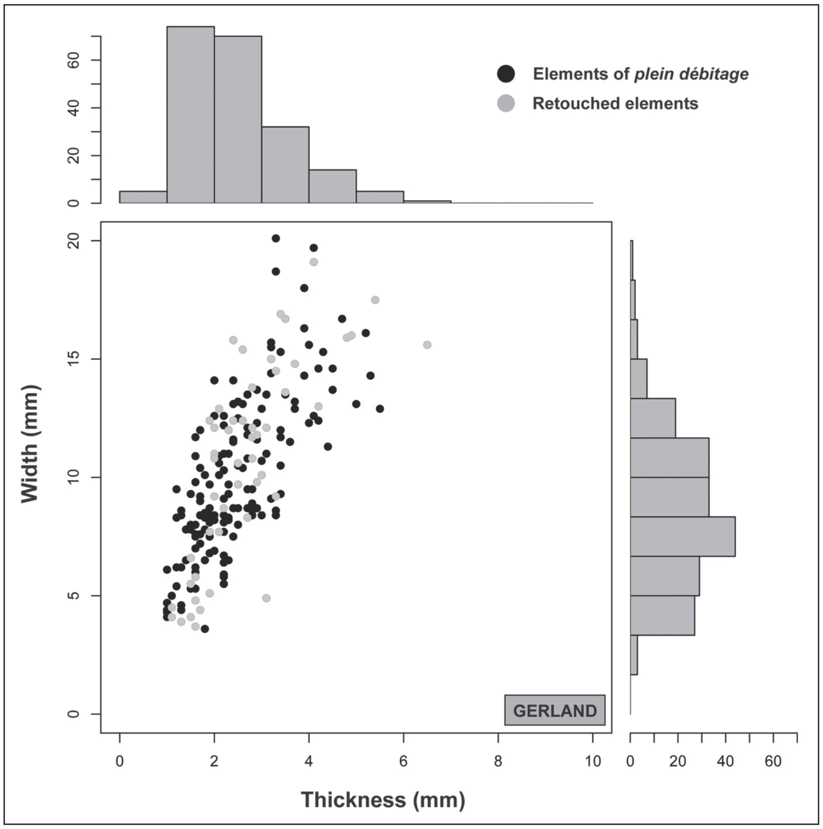


Figure 3.4. Typometric data (in mm) and frequency for all blades and bladelets of plein débitage, including retouched artefacts.

to have been the removal of large blades with a width of 12–14 mm, most probably by indirect percussion or direct percussion using a soft-stone percussor. (Figure 3.3, no. 3–5). Apart from the abrasion of the striking platform to facilitate blade removals, the angle and the surface of the striking platform were also revived by the removal of a 'tablet' flake from the platform surface perpendicular to the flaking surface.

Two flake cores complete the assemblage. The first one had the objective of producing large flakes from a unique circular platform. This flake core was of very poor quality, and the flaking surface was covered in negatives resulting from hinge flakes. The second core was used to manufacture what appear to be long flakes from a bi-directional 80° striking platform.

Blades and bladelets

The blade and bladelet sample from Gerland contains 274 highly fragmented artifacts and reveals a great variability in blank size (Figure 3.4). The range in width, averaging between 4 to 20 mm, suggests the existence of more than one episode of production within the assemblage. This can only be distinguished through a technological analysis.

Over 75 laminar proximal ends were carefully analysed (Figure 3.5). Among them, 71% of punctiform butts range between 4 and 8 mm in width, while 93% of plain butts are over 8 mm wide. Thus, two distinctive production tendencies have been observed within the assemblage: the first one is that of 6 mm wide bladelets, and the second is directed towards the production of 12 mm wide blades. The typology of arrowheads discussed below supports this statement.

Blades

The vast majority of blades are regarded as resulting from *plein débitage* (Table 3.3), meaning the removal of desired products rather than maintenance flakes. We first notice a balance between triangular (B1; 30.3%) and trapezoidal (C; 37.8%) sections. Beyond this, the presence of shaping (A1; 8.0%) and maintenance blades (A2; 15.0%), as well as the presence of a blade core, indicate that the *chaîne* opératoire of blade production may have been performed *in situ*.

Morphometric data demonstrates that the blade *débitage* is geared towards the production of pieces 12.0 ± 3.0 mm wide and 2.9 ± 1.0 mm thick (Table 3.4). Despite the high fragmentation of laminar products,

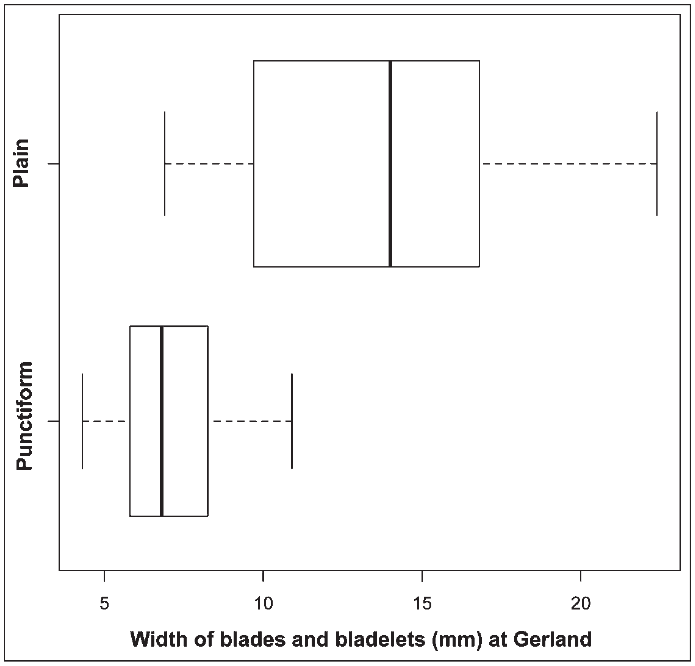


Figure 3.5. Boxplot showing the width of seventy-five proximal blades and bladelets, depending on whether they have a punctiform or plain butt.

			Blades		Bladelets	
Gerland: Blank details		*Code*	*N*	*%*	*N*	*%*
First blades (from unprepared core)		**A1a**	2	1.0%	0	0.0%
Cortical blades		**A1b**	14	7.0%	0	0.0%
Maintenance blades		**A2a**	15	7.5%	3	4.1%
	Lateral blades (right)	**A2b**	7	3.5%	6	8.2%
	Lateral blades (left)	**A2b'**	8	4.0%	1	1.4%
Blades of *plein débitage*						
	Triangular section (rythm 1-2/2-1)	**B1**	61	30.3%	37	50.7%
	More than three scars	**B2**	9	4.5%	5	6.8%
	Trapezoidal section (rythm 2-1-2')	**C1**	17	8.5%	5	6.8%
	Trapezoidal section (rythm 1-2-3/3-2-1)	**C2**	26	12.9%	8	11.0%
	Undetermined trapezoidal section	**C'**	33	16.4%	7	9.6%
Undetermined blades		**D**	9	4.4%	1	1.4%
Total			**201**	**100.0%**	**73**	**100.0%**

Table 3.3. Typology of blades and bladelets at Gerland.

Blades (n=146)	**Max.**	**Min.**	**Mean**	**C.V.**
Width (mm)	23.0	8.2	**12.0 ±3.0**	25.0%
Thickness (mm)	6.5	1.2	**2.9 ±1.0**	34.5%
Bladelets (n=63)	**Max.**	**Min.**	**Mean**	**C.V.**
Width (mm)	8.1	3.6	**6.1 ±1.4**	23.0%
Thickness (mm)	3.1	1	**1.7 ±0.4**	23.5%

Table 3.4. Typometric data (in mm) for blades and bladelets at Gerland. C.V. = coefficient of variation.

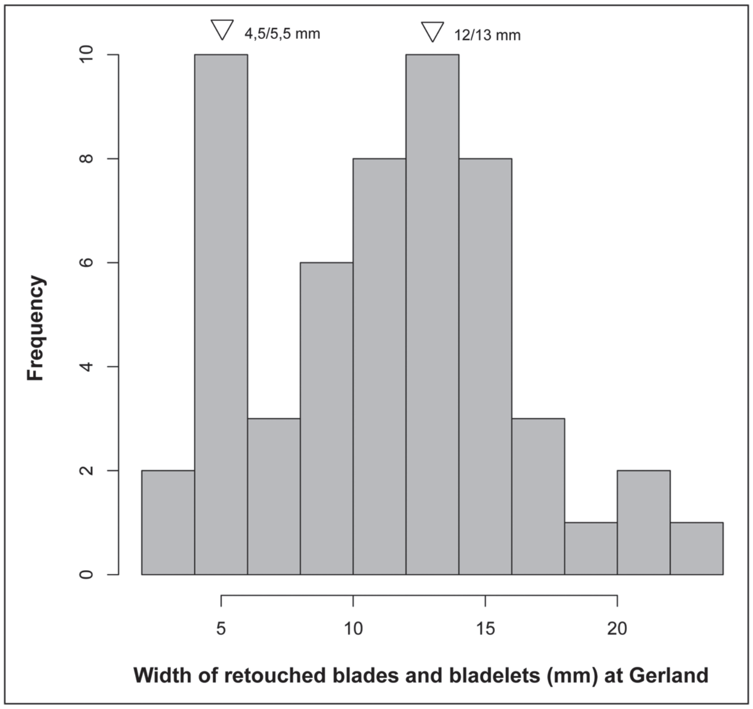


Figure 3.6. Frequency of all retouched blades and bladelets. A clear blade/bladelet opposition can be seen between geometrical arrowheads made on 12/13 mm wide blades and backed edges manufactured on 4.5/5.5 mm wide bladelets.

the proximal ends of 49 of them display mostly plain butts (51.0%), followed by cortical, facetted and linear. The bulbs are often scarred and the presence of a lipped butt is quite rare. All these diagnostic elements, to which we can add an 85° average gradient of the butts, could suggest that the technique of *débitage* was indirect percussion (Abbès and Der Aprahamian 2002; Pelegrin 2000).

Bladelets

Shaping bladelets (A1) are totally absent (Table 3.3). This could be explained by shaping the blocks through the extraction of flakes rather than bladelets. Among the *plein débitage* pieces, triangular bladelets sections are the dominant type (B1; 50.7%). Morphometric data indicates that the goal of bladelet *débitage* is the production of pieces 6.1 ± 1.4 mm wide and 1.7 ± 0.4 mm thick (Table 3.4).

Despite a sample of only 26 proximal ends, punctiform butts predominate (76.9%), followed by only a few linear and plain butts. The gradient of the butts lies between 75° and 80°, and the bulbs are often diffuse and sometimes scarred. This is highly representative of a direct percussion approach, using a soft-stone percussor (Abbès and Der Aprahamian 2002; Pelegrin 2000).

Flakes

Of the 312 flakes recovered, 95 are complete and may be attributed to shaping and maintenance of the bladelet cores (52.7%), while similar shaping and maintenance flakes resulting from the blade cores comprise only 5.3% of the total sample.

Tool Typology

The assemblage consists of 68 retouched artifacts, which represents some 3.6% of all the lithic material (Table 3.5). Blade tools are predominant, comprising 95% of the total retouched tools recovered, while flake tools represent only 5% of the dataset. Unlike shaping blades (A), which are rarely retouched (4.4%), the products of *plein débitage* (B and C) often show signs of retouch (80.8%). There are two main categories of diagnostic tools (Figure 3.6), divided into geometrical arrowheads (BG type) made on trapezoidal blades (C) and backed bladelets (BA type) produced from triangular bladelets (B1).

Geometrical arrowheads (n=30)

This category is represented by thirty arrowheads (Figure 3.7). These are mostly fragmented in the apical area, which is very common at numerous sites (see for instance Guilaine *et al*. 1979; Marchand and Michel

	Total	**A2**	**B1**	**B2**	**C**	**D**	**Flake**
Geometricals							
BG21	**1**	-	-	-	1	-	-
BG22	**6**	-	-	-	2	4	-
BG31	**1**	-	-	-	1	-	-
BG32	**8**	-	1	-	7	-	-
BG32'	**14**	-	-	-	11	3	-
Truncations							
TR23A	**1**	-	-	-	1	-	-
End-scrapers							
GR11B	**1**	-	-	-	1	-	-
GR21A	**1**	-	1	-	-	-	-
GR23	**1**	-	-	-	1	-	-
Burins							
BC13B	**1**	1	-	-	-	-	-
BC14	**1**	-	-	-	-	-	1
Microburins							
MB12C	**5**	-	1	2	2	-	-
Backed edges							
BA11A	**2**	-	-	1	1	-	-
BA11B	**1**	-	1	-	-	-	-
BA11C	**3**	-	2	1	-	-	-
BA12	**3**	-	3	-	-	-	-
BA13	**2**	-	2	-	-	-	-
BA42B	**2**	-	-	-	1	-	1
Irregular side removals							
IR22	**13**	2	4	-	8	-	-
IR21	**1**	-	-	-	-	-	1
Total	**68**	**3**	**15**	**4**	**37**	**7**	**3**

Table 3.5. Distribution of each typological tool according to the type of blanks. Typological codes are after Perrin (2003a).

2009). These 'points' are generally manufactured by reshaping the blade using inflection and inverse bitruncations, generally followed by direct low angle retouch. Nevertheless, five production methods have been identified, showing several variations around the identified 'norm':

1. One artifact is fashioned from a trapeze with two asymmetrical direct truncations (BG21).
2. Six are geometrical and display symmetrical direct bitruncations (BG22).
3. One arrowhead displays only two inverse bitruncations (BG31; Figure 3.7, no. 1).
4. Eight artifacts represent a technological evolution of the above method, with two inverse bitruncations and direct low angle retouch (BG32; Figure 3.7, no. 3–5).
5. The fifth category also indicates an evolution from the previous method of production. Fourteen pieces display a third step of manufacture characterised by direct steep retouch along each side of the arrowheads (BG32'; Figure 3.7, no. 6–11). However, this might reflect sharpening of these points after use.

Analysis of the arrowheads indicates a mean width of 12.5 ± 2.2 mm (cv=17.6%) (cv = coefficient of correlation) and a mean thickness of 2.6 ± 0.5 (cv=19.2%). These data demonstrate a homogeneous assemblage, which closely matches the technological observation of the blade production discussed above.

Backed bladelets (n=13)

As with the geometrical arrowheads, most of the backed bladelets are fractured and only one remains complete (Figure 3.8). Five different types have also been identified:

1. Two pieces show a straight-backed edge (BA11A).
2. One is crescent in appearance (BA11B; Figure 3.8, no. 1).
3. Three artifacts are characterised by two convergent straight-backed edges (BA11C; Figure 3.8, no. 2–3).
4. Three are scalene triangles (BA12; Fig. 3.8, no. 4–6).
5. Two are undetermined backed bladelets (BA13).

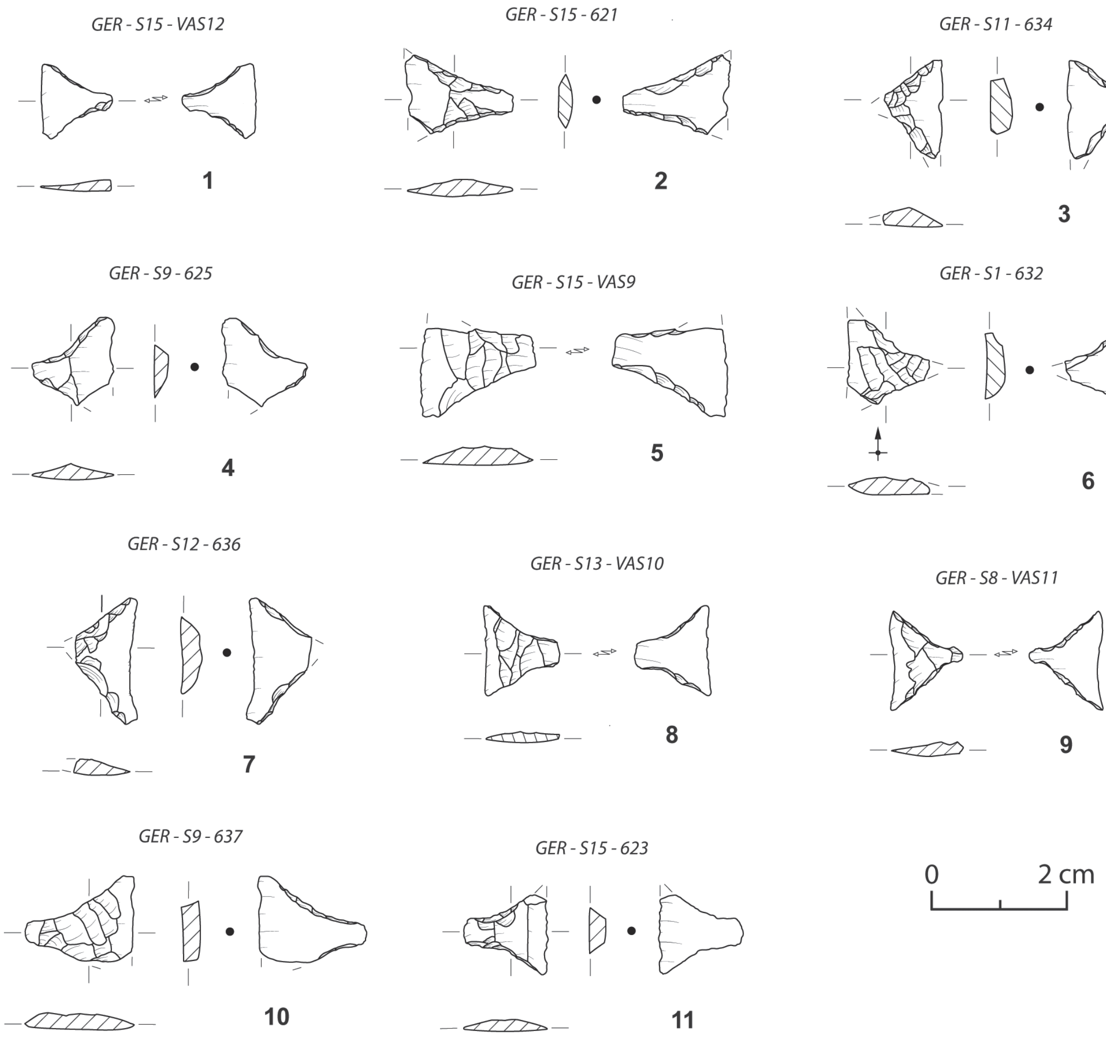


Figure 3.7. Geometrical transverse arrowheads: 1. geometrical with inverse bitruncations (BG31); 2–5. geometrical with inverse bitruncations and direct low angle retouches (BG32); 6–11. geometrical with inverse bitruncations, direct low angle and direct steep retouches (BG32'). CAD: A. Angelin.

Morphometric study indicates a mean of 4.6 ± 0.7 mm (cv = 15.2%) for the width and 1.6 ± 0.6 mm (cv = 37.5%) for the thickness. This data also demonstrates the homogeneity of the artifacts and corroborates our other technological observations.

Other tools

Irregular side removals are represented by fourteen pieces, most of which were made on blades (Figure 3.3, no. 6–9). Only one flake is retouched. Among the other tools, two end-scrapers have been produced from blades, with one other created using a flake. One truncated blade has been identified, along with two burins formed from a blade and a flake. Five microburins (average width: 8 mm) made on bladelets are also present within the assemblage.

Reconstruction of lithic production strategies at Gerland

Through the analysis of cores, blade blanks, and tools, we are able to reproduce two different *chaîne opératoires* (Figure 3.9). The first complete *chaîne opératoire* (No. 1) is directed towards the production of regular blades with a trapezoidal section through the use of indirect percussion, which are then used in the creation of geometric transverse arrowheads. The second (No. 2) involves the production of small bladelets by direct percussion with a soft-stone percussor that are transformed into backed bladelets. The presence of microburins in the assemblage allows us to raise some questions about their affiliation to either of the previous *chaîne opératoires*. However, the absence of

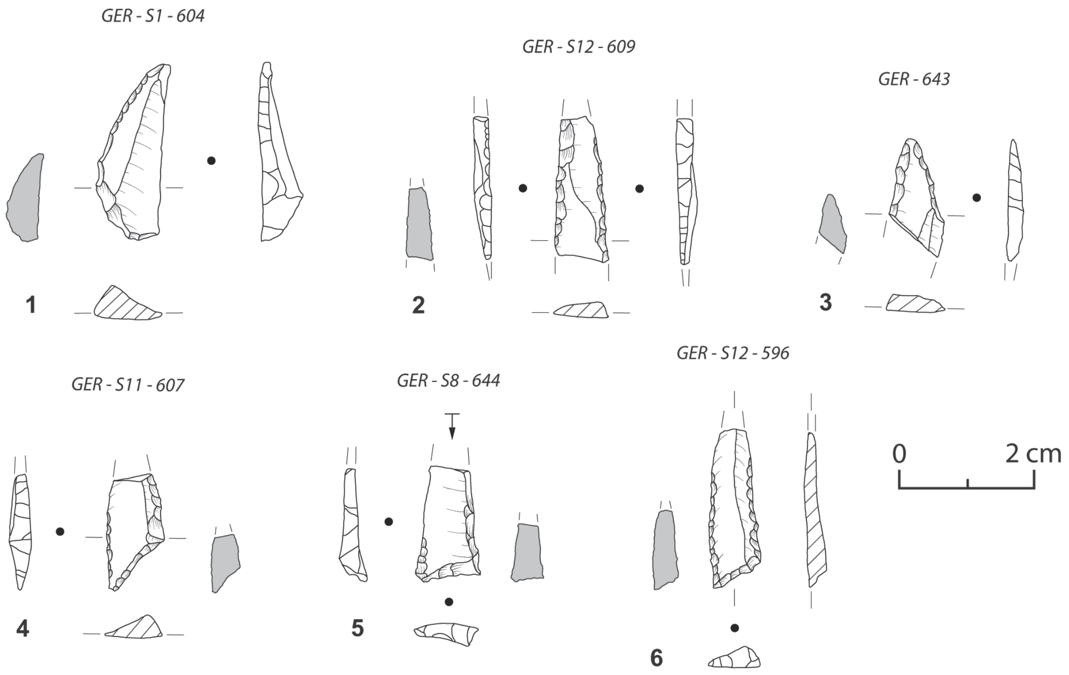


Figure 3.8. Backed edges bladelets: 1. crescent (BA11B); 2–3. convergent straight-backed edges (BA11C); 4–6. scalene triangles (BA12). The figures in grey are 1:1 scale. CAD: A. Angelin.

associated products remains unexplained. As a result, the microburins cannot yet be affiliated with a specific reduction sequence.

Analysis of the lithic industry at La Mare

The assemblage

The assemblage at La Mare contains 111 pieces of flaked flint (Table 3.6). With 84 artifacts available for study, the technological analysis is not as developed as that produced for Gerland. However, a sample of 34 retouched flints provided a typological analysis that is of interest.

Techno-typology

One flake core and two blade cores have been identified at La Mare. The first blade core was for the production of large, flat blades from a 75–80° unipolar striking platform using indirect percussion. These blades were removed frontally from a flaking surface that does not extend on to the flanks of the core (which contrasts with semi-circular and circular patterns of blade removal). The last blade removed has a width of 21.9 mm and a length of 61.9 mm. It is important to note the thickness of the core (26.7 mm), which might be the reason why it was abandoned. A second core also produced blades, although the blades were removed from the platform following a semi-circular pattern, and products were obtained from a facetted, 90° unipolar striking platform

La Mare: Blank types		**N**	**%**
Entire flakes		11	0.131
	Proximal fragments	12	0.143
	Other fragments	8	0.095
Entire blades		2	0.024
	Proximal fragments	23	0.274
	Mesial fragments	18	0.214
	Distal fragments	6	0.071
Blade cores		2	0.024
Flake cores		1	0.012
Quartz		1	0.012
Sub-total		**84**	**1**
Undetermined		12	
Splinters		13	
Debris		2	
Total		**111**	

Table 3.6. Composition of the lithic assemblage at La Mare.

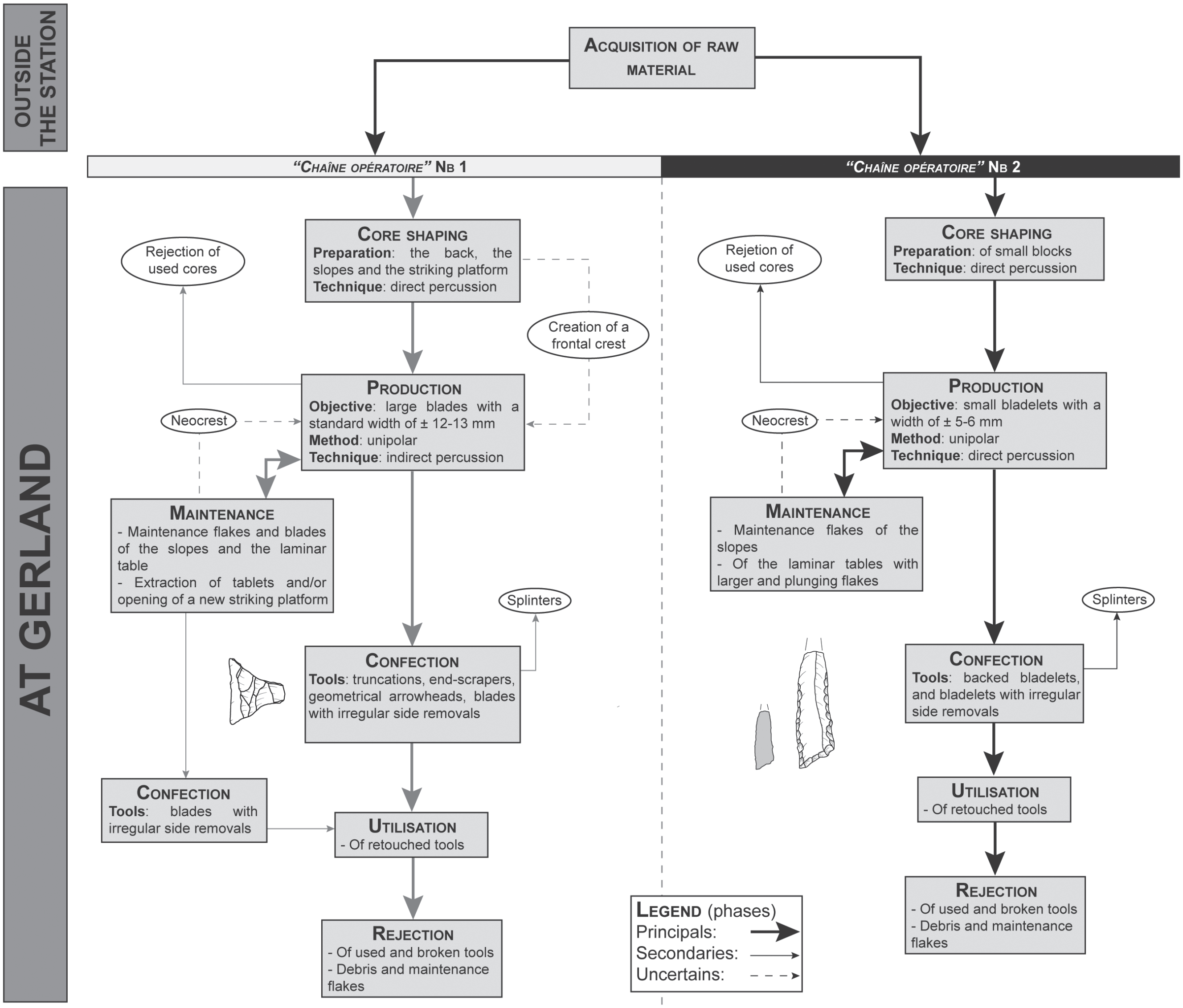

OUTSIDE THE STATION
ACQUISITION OF RAW MATERIAL
"CHAÎNE OPÉRATOIRE" NB 1
"CHAÎNE OPÉRATOIRE" NB 2
AT GERLAND
CORE SHAPING
Preparation: the back, the slopes and the striking platform
Technique: direct percussion
Rejection of used cores
Creation of a frontal crest
PRODUCTION
Objective: large blades with a standard width of ± 12-13 mm
Method: unipolar
Technique: indirect percussion
Neocrest
MAINTENANCE
- Maintenance flakes and blades of the slopes and the laminar table
- Extraction of tablets and/or opening of a new striking platform
Splinters
CONFECTION
Tools: truncations, end-scrapers, geometrical arrowheads, blades with irregular side removals
CONFECTION
Tools: blades with irregular side removals
UTILISATION
- Of retouched tools
REJECTION
- Of used and broken tools
- Debris and maintenance flakes
CORE SHAPING
Preparation: of small blocks
Technique: direct percussion
Rejetion of used cores
PRODUCTION
Objective: small bladelets with a width of ± 5-6 mm
Method: unipolar
Technique: direct percussion
Neocrest
MAINTENANCE
- Maintenance flakes of the slopes
- Of the laminar tables with larger and plunging flakes
Splinters
CONFECTION
Tools: backed bladelets, and bladelets with irregular side removals
UTILISATION
- Of retouched tools
REJECTION
- Of used and broken tools
- Debris and maintenance flakes
LEGEND (phases)
Principals:
Secondaries:
Uncertains:

Figure 3.9. Schematic of the different chaînes opératoires identified at Gerland. This graphic does not infer the contemporaneity of the assemblages. CAD: A. Angelin (modified from the original model after Perrin 2003a).

using indirect percussion (Figure 3.10, no. 1). The last blade removed was 17.9 mm wide and 71.0 mm long. The third core of the assemblage shows evidence of multidirectional flake removals using direct percussion. When a face became useless, the knapper appears to have switched striking platforms, often using the previous face as the new platform, continuing reduction until the core became unworkable.

The products comprise a total of 80 worked flints, of which blades are the dominant type. Flakes (n=31) can only be associated to the blade cores as the results of maintenance, while the origin of others remain undetermined, and no shaping flakes were identified. The absence of shaping flakes may be the result of the blocks being prepared elsewhere, rather than at La Mare. Regarding the products of *plein débitage* and their associated rhythms of production, there is no difference in proportion between triangular (type B1) and trapezoidal (type C) sections. Morphometric data demonstrates that the *débitage* is meant for the production of 13.1 ± 2.7 mm wide and 3.5 ± 1.2 mm thick blades. These values are comparable to one of the cores (Figure 3.10, no. 1) despite the last removal of a 17 mm wide blade. The use of indirect percussion prevails on the 25 proximal ends examined. However, it is not impossible that other techniques were used, such as direct percussion with a soft-stone percussor.

The assemblage also contained 34 retouched artifacts, which represent some 40.1% of all identifiable worked flint artifacts. Blade tools are the predominant type (85.3%), while flake tools represent only 14.7%. The main diagnostic tools are geometric transverse

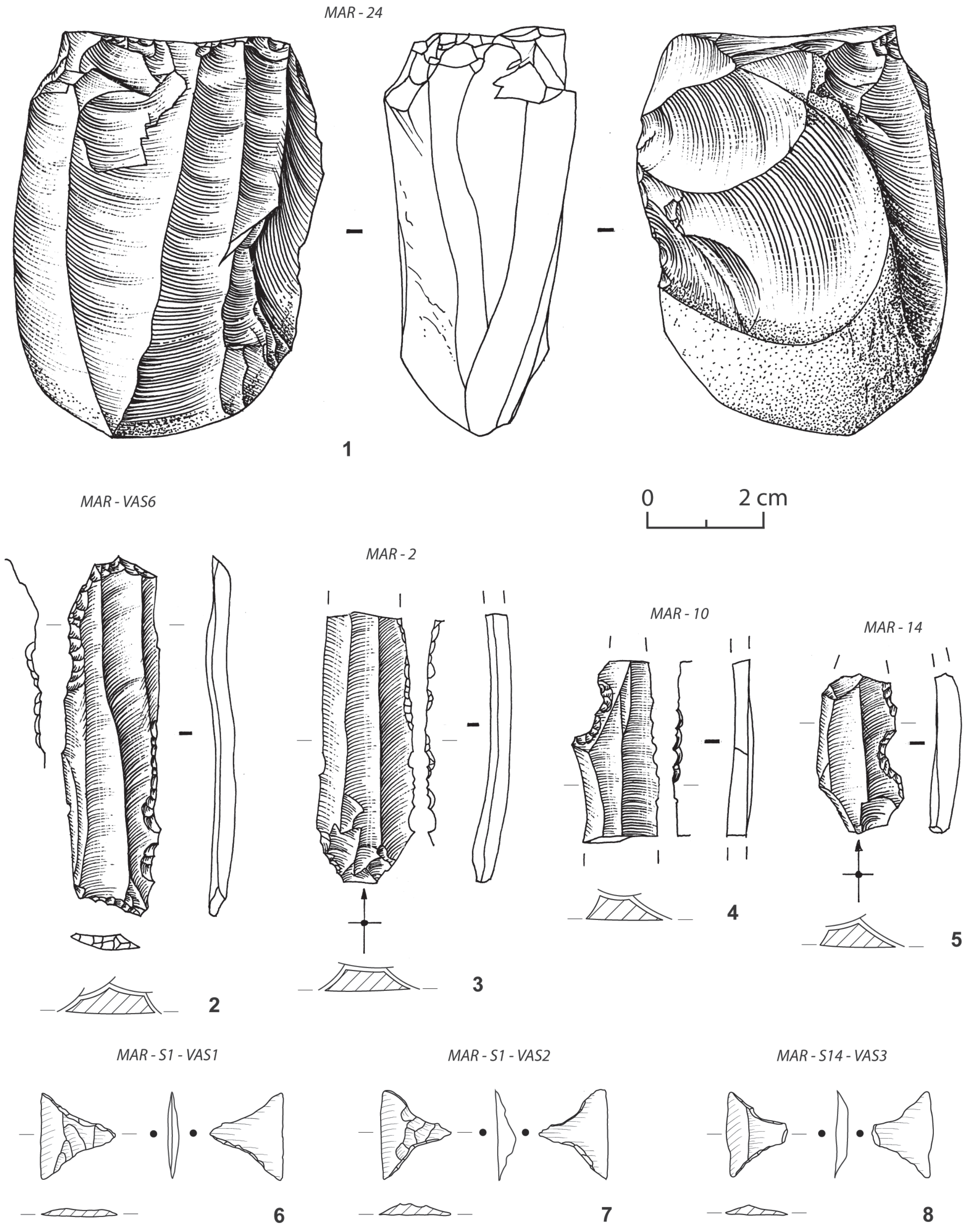


Figure 3.10. Lithic industry from La Mare: 1. blade core; 2–5. blades with irregular side removals; 6–8. geometrical transverse arrowheads. Drawings 1–5 by R. Picavet. CAD: A. Angelin.

arrowheads, which are represented by three pieces (Figure 3.10, no. 6–8). These were all made on blades and are technologically different from one another. One is made on a triangular blade section with two direct and steep truncations (BG22; Figure 3.10, no. 8). The others are made on trapezoidal blade sections. One is manufactured using inverse bitruncations and direct low-angle retouch (BG32; Figure 3.10, no. 7), while the other displays alternate bitruncations (one direct, one inverse) and three instances of direct low-angle retouch (BG34; Figure 3.10, no. 6). Other tools include five truncated blades, one side-scraper (also produced from a blade), and 23 irregular side removals (Figure 3.10, no. 2–5). Most of the latter were manufactured on blades, although five were made using flakes. Two microburins were also found, produced using small blades, with an average width of 9.0 mm.

Reconstruction of lithic production strategy at La Mare

Through the analysis of the cores, blade blanks, and tools, we can reproduce one main *chaîne opératoire* as well as three other different reduction sequences. The main *chaîne* is designed to produce blades from a core following a unipolar, semi-circular pattern. This mode of production seems to be displayed by numerous retouched laminar products (geometric transverse arrowheads, truncated blades, and irregular side removals).

Of the other three 'sequences', the first is geared towards the production of large flat blades. Evidence of this was observed on only one core. This appears to be a variation of the main *chaîne opératoire* described above, within which we could include this sequence. The second resulted in the production of very thin flakes. This is also represented by only one core, and it is consequently difficult to determine the ultimate aim of this approach. The third sequence is represented by two microburins, and cannot be affiliated with any of the sequences or *chaîne opératoire* outlined above. The absence of products directly linked to their manufacture remains unexplained.

Synthesis and Discussion

The techno-typology of knapped flint tools at Gerland and La Mare displays a great diversity of lithic material, probably from several millennia of human occupation. However, the evidence of heterogeneity is even more significant at Gerland than at La Mare. Given the technological seriations that allow us to delineate specific knapping objectives, we are now able to propose a chrono-cultural interpretation for each assemblage.

A chrono-cultural interpretation

Gerland: two technological and/or cultural traditions

Small bladelets for the creation of microliths

From a technological point of view, the first *chaîne opératoire,* aimed at the production of small bladelets for the creation of backed pieces, can be chronologically defined through regional comparison. Punctiform butts on most of the bladelets have been seen at the high altitude sites of Pré Peyret 1 (Picavet *et al*. 2008) and the Pas de la Charmate, Châtelus (Bintz 1995a), which is most likely linked to the middle Mesolithic and Sauveterrian culture. When compared to the south of France (Barbaza and Valdeyron 1991; Valdeyron 1994), the production sequence observed can be related to an early phase of the Sauveterrian. In regards to the cores, the production of small bladelets, which follows an opportunistic pattern, is similar to that from layers B3b and C of La Grande Rivoire, Sassenage (Picavet 1995, 1999), and at Pré Peyret (Pelletier in Picavet *et al*. 2008), which are also assigned to the Sauveterrian.

Therefore, in regards to typology, the backed bladelets at Gerland can be affiliated with some assemblages from the middle Mesolithic and the early and late phases of the Sauveterrian culture. They can be compared with artefacts from layers E4 and E3 of the Pas de l'Échelle, Rovon (Bintz 1995b), layer C2 of the Pas de la Charmate (Bintz 1995a), layers C and B3 of La Grande Rivoire (Picavet 1995 and 1999), the Balmettes shelter, St-Aupre (Monin and Pelletier 2000) and layers C2–4 of l'Aulp du Seuil, St-Bernard-du-Touvet (Bintz and Pelletier 2000; Pelletier *et al*. 2000). At high altitude and open-air sites, similar industries have been found in the Chaumailloux, Chichilianne (Bintz *et al*. 1999), at Source Chevalière, and at Pré Peyret. The absence of Sauveterre points in the assemblage suggests an early phase of the Sauveterrian. A scalene triangle showing retouch on three surfaces (Figure 3.8, no. 6) reminds us of the Montclusian culture, and the middle/late phase of the Sauveterrian.

The association with the south of France can be compared to many regional similarities within south-western France, such as Fontfaurès (Lot) (Barbaza and Valdeyron 1991). It has been noted that the microliths of the middle Mesolithic give an impression of continental-wide uniformity throughout Europe (Kozłowski 2009). Thus, this "could partly be due to the limited repertory of executable formal variants" (*ibid.* 35). Following this statement, we greatly encourage the development of further comparisons with industries from the Central Alps and northern Italy, where the Sauveterriano[1] has been identified for a long time (see, for instance, excavations in the Dolomites: Bagolini *et al*. 1984; Broglio 1993; and at Romagnano, Trento; Perini 1971; Flor *et al*. 2011). Even though some similarities can be found between these two complexes, diffusion of cultural indicators from northern Italy into the French Alps remains an unlikely hypothesis (Valdeyron 2008). For our assemblages, we can also refute the presence of northern influence, such as the Beuronian 'B' culture which occurs in the pre-alpine mountain range of Chartreuse, at La Fru (Pion and Thévenin 2007), and has not yet been identified in Vercors (Thévenin 1998).

To conclude, the production of bladelets for the creation of microliths at Gerland can be attributed to the middle Mesolithic, bearing affinities with southern complexes (early and/or middle/late Sauveterrian culture).

Larger blades for the creation of geometrical transverse arrowheads

The second *chaîne opératoire* is based on the production of larger blades (*c*. 12–13 mm wide), which were removed by indirect percussion (or punch technique), and used for the creation of geometric transverse arrowheads, exhibits mostly plain and/or linear butts. This kind of production is well documented in the early Neolithic seen in the south (Binder 1987). Recent studies at the cave of Gardon (Perrin 2003b) and at La Grande Rivoire (Nicod *et al*. 2012) have also produced similar results.

At Gerland, the best diagnostic tool remains the geometric transverse arrowhead, which is typical of the early Neolithic in southern France. In Vercors, they are found in layers B1 and d15–d28 (SU16–22) of La Grande Rivoire (Picavet 1999; Nicod *et al*. 2012), which has been dated to 5175–4420 cal BC. In the Chartreuse, similar pieces have been identified at the Balmettes shelter and are also attributed to the early Neolithic and Cardial traditions (Monin and Pelletier 2000). In the south of Vercors, some very similar arrowheads were discovered at the Corréardes shelter (Beeching *et al*. 1995) and are also undoubtedly related to the Cardial culture (Chaffenet and Cordier 1999). Nevertheless, the thirty geometric arrowheads identified, along with the specific *chaîne opératoire* linked to their production, indicate "the existence of contacts with Mediterranean Neolithic or very Late Mesolithic groups, themselves in contact with farmers" (Marchand and Michel 2009, 121).

We did notice a great variability of technological manufacture for the geometric pieces in the assemblage. We also observed an evolution of these points characterised by probable sharpening of the edges by direct steep retouch. This has also been observed at numerous other settlements, see for instance at Jean-Cros shelter (Guilaine *et al*. 1979) and, more recently, at La Grande Rivoire (Nicod *et al*. 2012). The nature of this variability remains, however, unclear at this time and there is no evidence of any chrono-cultural influences within the assemblages. Systematic refitting of lithic material may be able to offer some new perspectives.

La Mare at the Pas de l'Aiguille

Many of the knappers' objectives can be plainly observed at La Mare. One of them is the production of large and flat blades for the creation of truncated blades and geometric arrowheads, which can be compared to the 'Vercusian' culture of Vassieux-en-Vercors, Drôme (Malenfant *et al*. 1995; Pelegrin *et al*. 1999). Dated to 5500–4800/4700 cal BC, these artefacts can be attributed to the early Neolithic (Riche 2002).

The association of three technologically distinct types of geometric arrowheads within a single assemblage (BG22, 32 and 34, Figure 3.10, no. 6–8) has three possible explanations: three micro-traditions of production belonging to one group; the results of three different chronological cultures; or the remains of three different synchronous groups. At Balmettes, the BG22 type is understood as a late/final Mesolithic tool (Monin and Pelletier 2000). Thus, we could join together some irregular side removals (Figure 3.10, no. 2–5), also called Montbani, which may be related to the late Mesolithic and Castelnovian culture. Nevertheless, the combination of these three technologically different arrowheads is quite common for the early Neolithic. See, for instance, settlements such as Fontbrégoua and Baratin at Courthézon (Binder 1987), and others in Languedoc (Briois 2000).

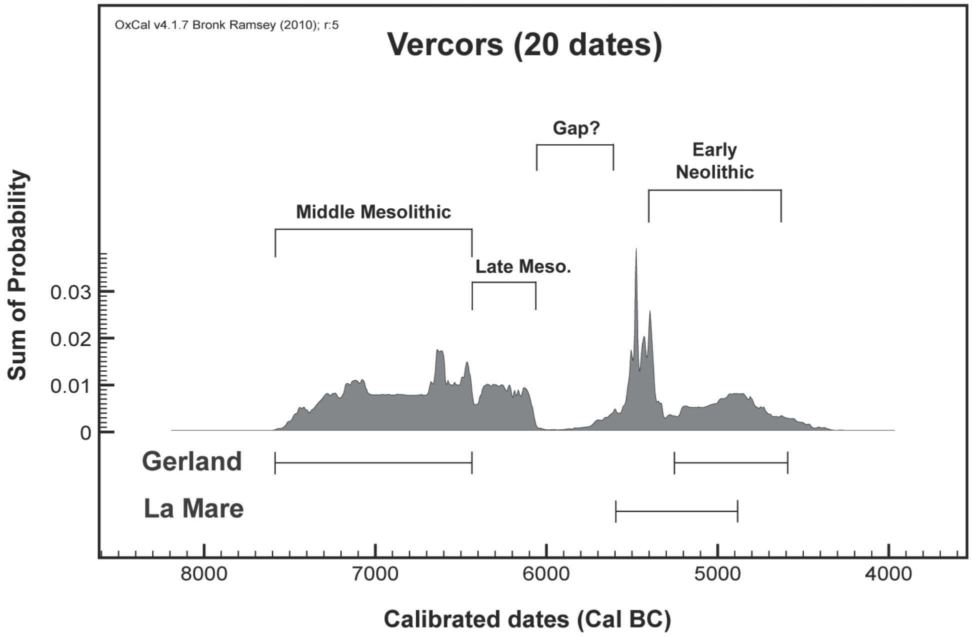
Until now, these arrowheads have always been attributed to the early Neolithic with southern affinities, exhibiting a complete departure from the late Mesolithic (Binder 1987). Regardless, recent excavations at Cuzoul de Gramat (Valdeyron *et al*. 2011) and La Grande Rivoire (Nicod and Picavet 2003; Nicod *et al*. 2012) indicate that these arrowheads are not only present in early Neolithic layers, but also just above Mesolithic occupations, sometimes in association with Mesolithic industries. For Valdeyron, these elements are seen as a persistence of Mesolithic traditions within Neolithic industries (Valdeyron *et al*. 2011). It remains to be seen how the discussion of these artefacts will be resolved.

Finally, three hypotheses regarding the Prehistoric occupation of La Mare are proposed. It is possible that there were two distinct, but chronologically adjacent occupations; a 'final' Mesolithic and a 'very early' Neolithic. The second hypothesis would see the assemblage of La Mare as a Meso-Neolithic transition comprising of a mixed assemblage. Finally, the third, and in our opinion the most likely assumption, is that La Mare can be interpreted as an early Neolithic occupation with similarities to southern occupation, and an assemblage that is quite homogeneous, despite some intrusive pieces from an older period.

Synthesis

The sites of Gerland and La Mare offer us two distinctive chrono-cultural sequences: on the one hand we have a Sauveterrian middle Mesolithic at Gerland followed by a chronological gap before resettlement in the early Neolithic, and on the other is an early Neolithic occupation at La Mare with similarities to southern materials.

In Vercors, radiocarbon dating has been conducted at Pas de la Charmate (Bintz and Picavet 1995), La Grande



Settlement	Layer	Lab. ID	Sample	BP	Calib. 2σ	Reliability	Attribution
Charmate E	C1 top	Ly-3786	Charcoal	7820 ± 120	7038 - 6466	Good	MM/LM
Charmate E	C1 base	Ly-4380	Charcoal	7950 ± 100	7128 - 6595	Good	MM/LM
Charmate E	C2b	Ly-4204	Charcoal	8240 ± 260	7937 - 6531	Uncertain	MM
Charmate E	C2b base	Ly-5245	Charcoal	9100 ± 250	9121 - 7602	Uncertain	MM
Charmate E	C2b base	Ly-4379	Charcoal	7430 ± 120	6492 - 6051	Average	LM
Charmate O	C1 base	Ly-5661	unk	8020 ± 100	7293 - 6646	Uncertain	MM
Charmate O	C2a top	Ly-5662	unk	8100 ± 100	7418 - 6696	Uncertain	MM
Charmate O	C2a base	Ly-6006	unk	8140 ± 60	7344 - 6867	Average	MM
Grande Rivoire	B1b	Ly-4447	unk	5820 ± 140	5007 - 4361	Average	EN
Grande Rivoire	B1b	Ly-176(OxA)	unk	6000 ± 70	5195 - 4718	Average	EN
Grande Rivoire	B2a	Ly-5185	unk	6195 ± 87	5357 - 4912	Average	EN
Grande Rivoire	d26 (SU16-22)	Beta-282246	Bone	6510 ± 40	5548 - 5373	Good	MN
Grande Rivoire	d28 (SU16-22)	Beta-255118	Bone	6430 ± 50	5479 - 5320	Good	MN
Grande Rivoire	d28 (SU16-22)	Beta-282247	Bone	6490 ± 40	5529 - 5367	Good	MN
Grande Rivoire	B2b	Ly-5099	Charcoal	6649 ± 142	5837 - 5325	Average	MN
Grande Rivoire	d30 (SU16-22)	Beta-255119	Bone	7310 ± 40	6236 - 6071	Good	LM
Grande Rivoire	B3	GrA-25066	Bone	7435 ± 45	6409 - 6229	Good	LM
Grande Rivoire	d34 (SU16-22)	Beta-282248	Bone	7790 ± 40	6688 - 6506	Good	MM/LM
Grande Rivoire	C	Ly-5433	unk	8280 ± 80	7515 - 7083	Average	MM
Grande Rivoire	D	Ly-5434	unk	8740 ± 110	8206 - 7589	Uncertain	MM
Balme-Rousse	C1b	Ly-3043	Bone	6020 ± 150	5304 - 4561	Average	EN
Coufin 1	F2	Ly-1730	Charcoal	6230 ± 240	5630 - 4617	Uncertain	MN
Coufin 1	F7	Ly-2106	unk	8200 ± 140	7542 - 6779	Average	MM
Coufin 2	F11	Ly-3648	unk	7810 ± 140	7057 - 6435	Average	MM/LM
Pas de l'Échelle	D4	Ly-7094	Bone	6940 ± 65	5983 - 5716	Uncertain	MN
Pas de l'Échelle	D4	Ly-3945 (OxA)	Bone	7615 ± 40	6568 - 6412	Uncertain	LM
Pas de l'Échelle	E1	Ly-4686	Bone	7630 ± 50	6592 - 6421	Good	LM
Pas de l'Échelle	E3	Ly-7095	Bone	8050 ± 95	7306 - 6683	Good	MM
Pas de l'Échelle	E4	Ly-4598 (GrA)	Bone	8695 ± 40	7825 - 7594	Uncertain	MM

Figure 3.11. Top: sum of probability for radiocarbon dating of Vercors with good and average reliability (OxCal v4.1: Bronk Ramsey 2009). Bottom: radiocarbon dating of Vercors with 2 sigma calibration after IntCal 09 (Reimer et al. 2009). MM: middle Mesolithic; LM: late Mesolithic; MN: Meso-Neolithic; EN: early Neolithic. CAD: A. Angelin.

Rivoire (Picavet 1999; Nicod *et al*. 2012), Balme-Rousse and Coufin 1 and 2 (Bintz and Picavet 1995), and Pas de l'Échelle (Bintz 1995b; Bintz and Millet, forthcoming). Few radiocarbon dates have been rejected, and twenty dates have enabled us to place the different techno-complexes within a precise chronological framework (Figure 3.11).

The occupation at Gerland would most probably have begun during the middle Mesolithic, from around 7800 cal BC until 6700/6600 cal BC. After the desertion of the site, the resettlement by the first Neolithic peoples occurs around 5300 cal BC. At La Mare, the activity seems to span a much shorter period. Also, the presence of intrusive late Mesolithic industries pushes us to place this Prehistoric occupation around 5500–5000 cal BC, during a period of contact between the last hunter-gatherers and the first farmers.

Conclusion

This study deals with new perspectives on occupation and the territorial use of high altitude areas during the early Holocene. If typological seriations for the lithic tools seem to be easily created, the heterogeneity of most of the assemblages in the alpine region of Vercors makes technological interpretations much more difficult. The difficulties faced in delineating the Sauveterrian culture and Neolithisation processes are an example of this, but confronting these impasses head on can lead to important results, as has been demonstrated in this paper.

Finally, what can be said about the function of these sites? Can they be interpreted in the same way as typical low and mid-altitude rockshelters? Years ago, hunting camps, or 'hunting stands' (Binford 1980) would have been the only reasonable explanation. It is now recognised as a far more complex issue, and we should consider motivations other than just hunting. The absence of faunal remains at high altitudes, due in part to alterations in taphonomy at this height, is very common in the periglacial zone within the Alps (Fedele 1999) and prohibits any assessment of seasonality. The goal here was not to develop occupation schemes for interpretation based upon scarce data. However, for further investigation, comparisons with other regions, such as Switzerland, the Central Alps, and the Dolomites region where prehistoric research is far more advanced, are desperately needed. Examples of such research include the work done at Colbricon (Bagolini and Dalmeri 1987) and the discoveries in the Spluga Valley of sites at 2000 m AMSL and above the present day timberline (Fedele 1999).

At present it is a priority to establish a reference base of open-air settlements for comparison in Vercors region. A thesis on the Mesolithic sequence of the rock shelter of La Grande Rivoire (Sassenage, Isère) is underway and may soon bring to light some very interesting results. Moreover, the development of prospection at high altitude in pre-alpine mountain ranges and beyond remains essential for understanding the motivations for prehistoric groups settling and occupying alpine areas.

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Note

1. We would like here to clarify the use of *Sauveterriano*, which differs from the Sauveterrian. First encountered and designated at the Martinet shelter in Sauveterre-la-Lémance, Lot, France, the term 'Sauveterrian' (Sauveterrien in French) is used to designate the middle Mesolithic culture from the south of France. The term *Sauveterriano* is a derivation of the French word and is used specifically to designate the first Mesolithic cultures encountered in northern Italy (see for instance the assemblage from Romagnano shelter) where a very similar microlithic typology can be found.

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4. The Phenomenon of Mesolithic Settlement within the Bohemian Paradise Area, Czech Republic

Petr Šída, Marta Moravcová, Dagmar Vokounová Franzeová and Jan Prostředník

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Introduction

This paper summarises the current understanding of Mesolithic settlement within the area of Bohemian Paradise, Czech Republic, and presents the phenomenon of Mesolithic settlement in local rock shelters and caves. Specifically, it presents a synthesis of data based on the archaeological research and publications of Šída and Prostředník and makes a comparison with data from around Česká Lípa district, which has long been under review by Svoboda (2001, 2003). The main components of this synthesis are technological composition and use of raw materials for the production of chipped stone assemblages. Determination of raw materials portrays, amongst other things, a picture of Mesolithic hunter-gatherer movements. Technological analysis, which divides the chipped stone industry into the major technological groups, such as cores, semi-products, tools and production waste, established the character of Mesolithic sites from the point of view of relations between production and consumption.

Bohemian Paradise and the location of studied Mesolithic sites from Semily district

The Bohemian Paradise is a protected landscape area located in the north of the Czech Republic, nearly fifty kilometres to the northeast of Prague. It occupies an area of around 1800 square kilometres. This area borders with the Krkonoše Mountains in the east and the Jizerské Mountains to the north. The landscape of the Bohemian Paradise is slightly warped and unique thanks especially to numerous sandstone 'rock towns' and volcanic basalt fingers (Figure 4.1).

The sites of Babí pec, Kudrnáčova pec, and Zemanova pec lie to the west and north-west at the base of Kozákov hill. In addition, the so called Kristova jeskyně is part of the Klokočské skály rock area, and the site of Hlavatá skála is located in the Borecké skály rock area (Figure 4.1). These archaeological sites represent rock-shelters, caves, or abri of different sizes.

History of the researches in Bohemian Paradise

Despite relatively intense, centuries-long research, the region of the Bohemian Paradise continues to be poorly understood archaeologically. For a long time, Late Palaeolithic and Mesolithic finds were not known in the region. The largest collections of chipped stone industries were found prior to the Second World War. In view of contemporary methods of field work, however, they were not stratified and were dated to the Eneolithic for several decades (Filip 1947, 23–25; Šída 2007, 117–118). Thanks to a review of the finds and re-opening of old investigations in recent years, Šída and Prostředník have been able to expand the number of Mesolithic localities to nineteen. In addition, they have proceeded to carry out new excavations (see Šída and Prostředník 2007, 2010).

Modern Czech research of Mesolithic settlements in pseudo-karst rock shelters started in 1950, with the work of Prošek and Ložek (1952) at Zátyní. This was the first time the Mesolithic had been identified in an excavation in the Czech Republic; nevertheless, the material from this archaeological site was not dated to the Mesolithic period. The largest assemblages of chipped stone were found at the beginning of the twentieth century at Hlavatá Skála, Ludmilina jeskyně, and Zemanova Pec, in excavations conducted by the

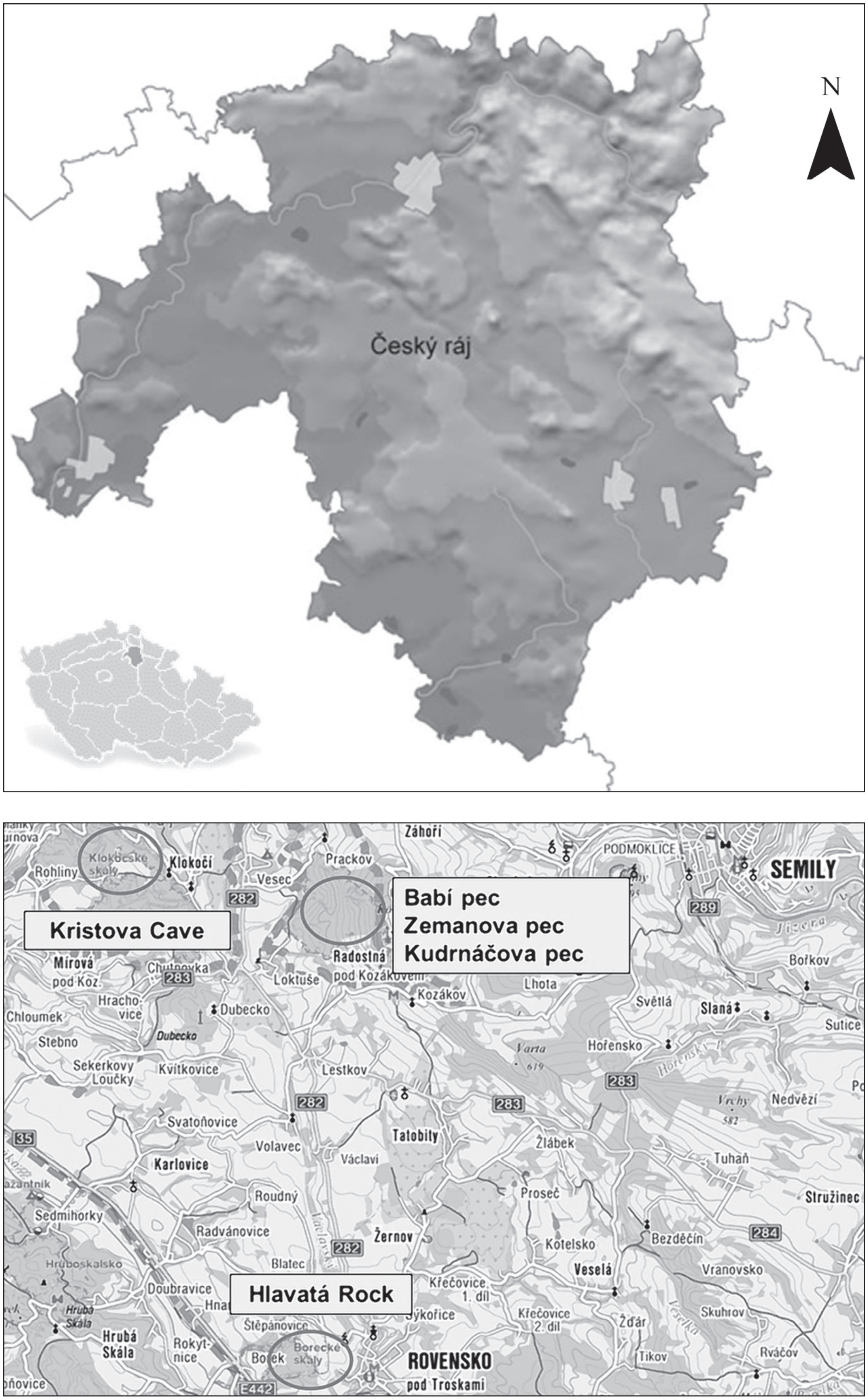

Figure 4.1. Geographical location of Bohemian Paradise, including the archaeological sites under study.

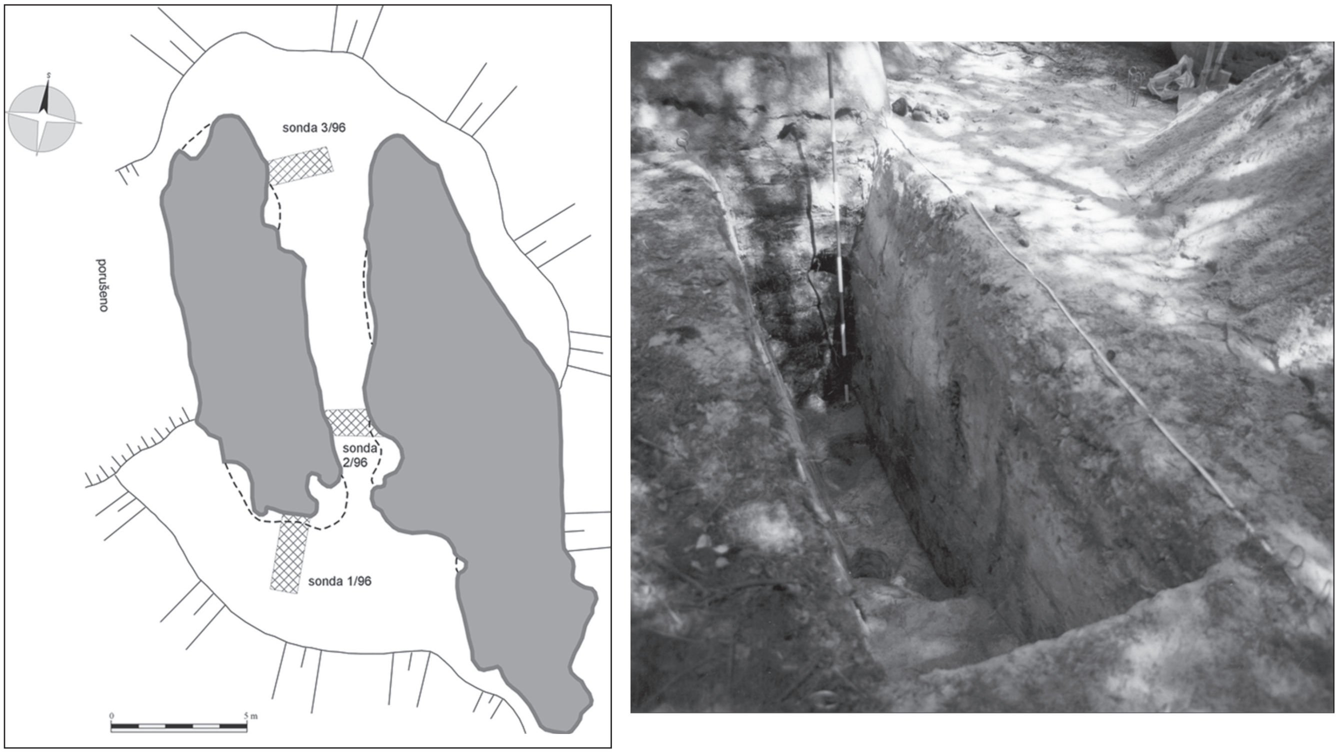

Figure 4.2. Research at Hlavatá skála conducted by V. Vokolek in 1996.

archaeological cooperative of Šimák and Vaníček (Šída and Prostředník 2007, 444; Šimák 1910). From the latter site a collection of Mesolithic chipped stone and osteological material was obtained. Other assemblages were collected by Vaníček and Šimák from Babí Pec and Kudrnáčova Pec between 1936 and 1937. A collection of Mesolithic chipped stone with Eneolithic admixture was recovered from Kudrnáčova Pec, while at Babí pec the largest collection of Mesolithic chipped stone was obtained. However, these were also not identified as Mesolithic at the time of excavation (Svoboda 2003, 11–18).

Following this investigation, two reviews of the research were conducted, first by Prošek and Jisl in 1947 and the second by Šída and Prostředník in 2003 and 2006. The latest excavations with an unidentified Mesolithic layer were carried out by Vokolek at Hlavatá Skála (Vokolek 1998). In Trench 1, in the southern part of the site, he identified a thick cluster of tree cultural layers with hearths, but found no artefacts. In 2005 we used charcoal from the second (middle) layer of these fireplaces to obtain the very first Mesolithic date for a site in Český Ráj (Šída-Prostředník 2006; Figure 4.2). In 2010 Šída and Prostředník reopened this trench, sieved the fill, and found several dozen Mesolithic artefacts. The Museum of the Bohemian Paradise, in cooperation with the National Museum in Prague, carried out a rescue excavation in 2005 at a site that had been interfered with by a metal detectorist. A total of five Mesolithic hearths and one pit were excavated in an area of three square meters. At fireplace 5 a number of hazelnuts shells were found.

Mesolithic hunters from Semily district versus Mesolithic settlers in Česká Lípa and Děčín district

As was mentioned in the introduction, the main topic or scientific question of our research was whether there exists a difference between various parts of Bohemian Paradise from the point of view of archaeological resources. Here we will compare results from archaeological research into Mesolithic sites in the Semily district and long-term excavations at caves and rock-shelters in Česká Lípa and Děčín districts conducted by Svoboda *et al*. (Figure 4.3). Our discussion focuses on raw material economy and technological composition of the chipped stone industry.

Lithic materials and composition of chipped stone industries from Semily district

An overview of the percentage of stone raw materials in assemblages under study can be seen in Table 4.1.

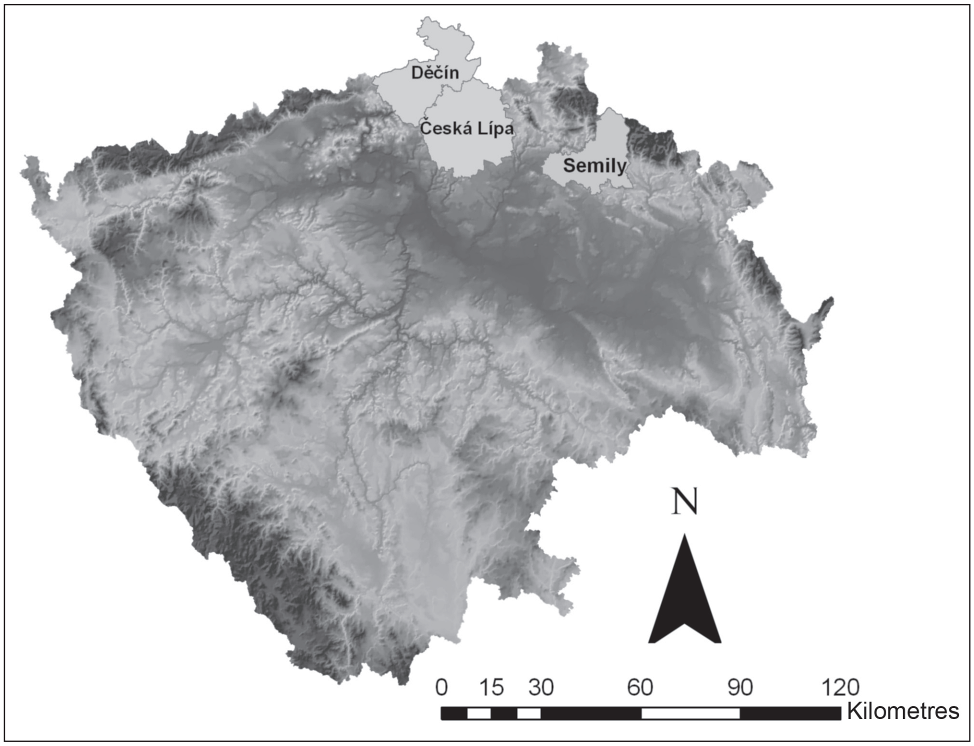

Figure 4.3. Geographical location of the district under study.

Jasper of various colours was the most frequently used raw material in the chipped stone industry obtained during excavations of Mesolithic sites in Semily district (specifically during excavation at Babí pec, Zemanova pec, Kudrnáčova pec, Kristova jeskyně, and Hlavatá skála). A total of 839 pieces were made on jasper. Six hundred of these come from Babí pec alone. This site has the richest assemblage based on the number of chipped stone artefacts recovered, with a total of 1341 pieces. In the case of Babí pec and Kudrnáčova pec, jasper represents the main raw material. For the remaining three archaeological sites, this material is the second or third most frequently used. Beside jasper the assemblages also contains a mineral known as opal-jasper (from the point of view of their genesis something between opal and jasper). The second most abundant lithic materials present are silicates originating from glacial and glaciofluvial sediments, or so called drift flints, from which a total of 565 pieces were made (see Table 4.1, first line). Artefacts made from burnt silicates are most probably also part of the drift flints. All the other raw materials do not form more than 6 % of the total number of artefacts.

Sources and transport distances of drift flints

Silicates originating from glacial and glaciofluvial sediments (SGS) occurred in the territory in northern Bohemia that was glaciated by Pleistocene continental ice sheets, bringing so called flints from northern Europe as erratic material. The origin of the flints must be from within this area, as there are no natural occurrences of flints in Bohemia. A hunter-gatherer could also obtain flint from rivers flowing through the glaciated area (Evans-Twigg 2002, 2150, 2167; Přichystal 2004, 46–49). Their transport distance is in the range of 10–30 km (Figure 4.4). The group of flints probably also includes a part of the raw material referred to as not-determine and burnt silicate.

Sources and transport distances of north-west Bohemian quartzites

With the exception of the collection from Kudrnáčova pec, quartzite was present in all the chipped stone assemblages and was determined to originate from north-west Bohemia, from an area located between the towns of Most and Kadaň (Malkovský-Vencl 1995). While their number is insignificant, the use of quartzite of the Bečov, Skršín, and Tušimice type is important evidence of contact with north-west Bohemia, where Mesolithic settlers found the highest quality sources of quartzite in the Bohemian region on the surface of natural outcrops. The Bečov type quartzite originates from the Písečný and Bečovský hill, as the nearest outcrop of the quartzite types mentioned lies more than 90 km from Semily district (Figure 4.4).

	Site				
Type	*Babí pec*	*Zemanova pec*	*Kudrnáčova pec*	*Kristova jeskyně*	*Hlavatá skála*
SGS	19.1	51.4	14.9	26.3	40.2
ND Silicite	0.5	4.2	3	1.3	4.6
Overburn Silicite	10.1	-	-	44.5	0.4
Bečov Q	0.1	1.4	-	-	-
Tušimice Q	0.1	-	-	0.4	1.1
Skršin Q	-	-	-	-	0.4
ND Q	1.2	-	-	-	-
Jasper	44.7	34.7	67.3	13.4	11
Jasper-agate	0.1	-	-	-	-
Agate	0.3	-	-	-	0.4
Opal-jasper	11.9	4.2	2.4	4.1	17.9
Opal	0.1	-	-	-	-
Chalcedony	1	-	-	0.4	-
Crystal rock	0.3	-	-	0.4	-
Other Kozákov Hill	1.3	-	5.4	0.2	0.4
Porcellanites	1.3	2.8	2.4	0.6	3.4
Metabasic JH	2.3	-	3.6	0.8	1.9
Plattensilex	0.4	-	-	-	-
Quartz	2	-	0.6	1	2.7
Other local	3	1.4	0.6	6.9	15.2
ND	0.2	-	-	-	0.8

Table 4.1. Overview of the percentages of stone raw materials in Semily district.

Sources and transport distances of minerals from Kozákov hill

Red or green coloured jasper and other minerals, such as agate, opal, chalcedony and their derivatives, including opal-jasper and agate-jasper, have their origins in Permian melaphyres, first of all at Kozákov hill, but also at numerous other places within Semily district (Přichystal 2004, 14–15). Therefore, these resources are available in the immediate vicinity of the archaeological sites under study. The use of local minerals, mainly jasper, is a characteristic feature of the chipped stone assemblages obtained at Mesolithic sites in Semily district. Of interest is the occurrence of metabasite of the Jizerské hory type. This local raw material is accessible up to 10 km from Mesolithic settlements and was frequently used in the Neolithic as a material for the production of polished axes (Šída-Kachlík 2009). Also amongst the locally sourced rocks are green coloured porcellanites, which represent porcelaneous rocks resulting from thermal metamorphism around igneous rocks of burnt layers of coal (Přichystal 2004, 27). These are transported distances of less than 10 km, although the favoured outcrops are found on the hill known as Kunětická hora, which is about 65 km away. On the other hand, red coloured porcellanites originate in north-west Bohemia around outcrops of the Bečov type quartzite and was probably transported together with this quartzite.

Plattensilex (slab-like chert) was identified at Babí pec, where it makes up 0.4% of the collection. Outcrops of this type of chert are localised in Bavaria around the towns of Arnhofen, Baiersdorf, Painted, and Eichstätt (Engelhardt-Binsteiner 1988, 8–27; Přichystal 2009, 87). The occurrence of this raw material, which is exotic for northern Bohemia and comes from a distance of 250 km, indicates contacts with Bavaria and implies that the route through the Plzeň basin to the southwest to Bavaria, via the Všerubský pass, must have been used. Plattensilex occurs in larger quantities at Mesolithic sites in western and southern parts of Bohemia, which would fit with the used of this transport corridor. In

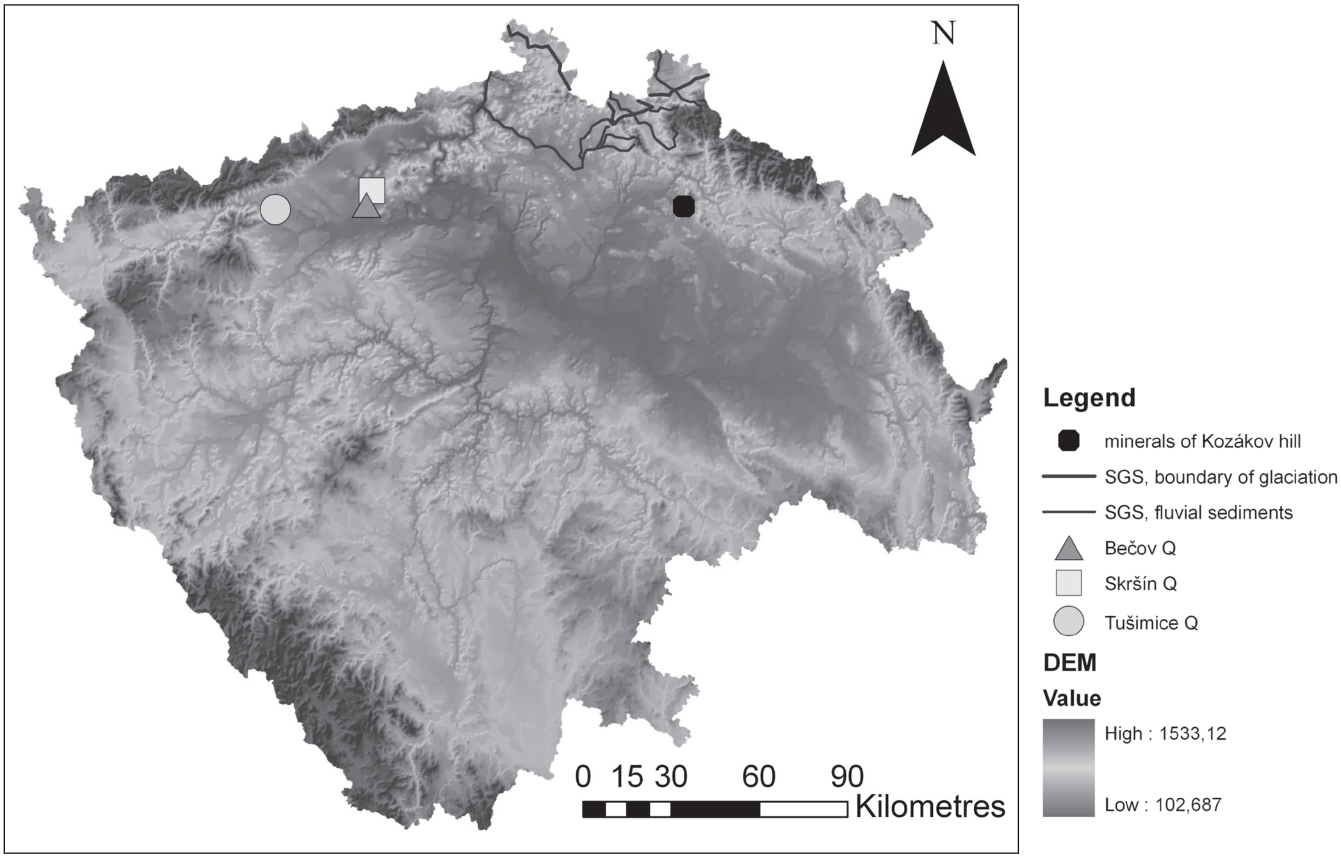

Figure 4.4. Geographical locations of lithic material outcrops used.

some cases this material appears in assemblages of chipped stone containing quartz and other local raw materials.

Technological composition of chipped stone industries from Semily district

The technological analysis is based on the composition of major technological groups, such as production waste (fragments and chips), semi-finished products (flakes and blades), retouched tools (geometric microliths, end-scrapers, burins, backed blades and flakes, notched pieces), and cores.

The most frequent are two technological groups, production waste (the range of values is between 21 and 64%) and semi-finished products (percentages in particular assemblages range from 25 to 64%). However, in some cases differentiating between flakes that are production waste and those that represent semi-finished product is a problem.

The tools make up *c*. 5% of the Kristova jeskyně, Kudrnáčova pec and Babí pec assemblages or *c*. 9–10% of the Hlavatá skála and Zemanova pec collections. A small portion of the chipped industry is made up of cores (Figure 4.5).

Lithic materials and composition of chipped stone industries from Česká Lípa and Děčín districts

In terms of Mesolithic sites in Česká Lípa and Děčín districts and the results of research conducted by Svoboda and others (Svoboda 2003), the prevailing stone raw material in almost all the assemblages is drift flints. The amount of flint used ranges from 26.3 to 100%. The lowest value is connected with the industry found at Nosatý kámen (Děčín district). This site represents an exception in terms of stone raw material economy, as the most frequently used raw material in this region is not flint, but the Tušimice type quartzite.

From the point of view of the raw material composition of the chipped stone industries, which is based on a summary of all stone artefacts from 27 sites in the Česká Lípa and Děčín districts (Svoboda 2003), the larger part presents non-determinate and mostly burnt rocks. All other raw materials do not

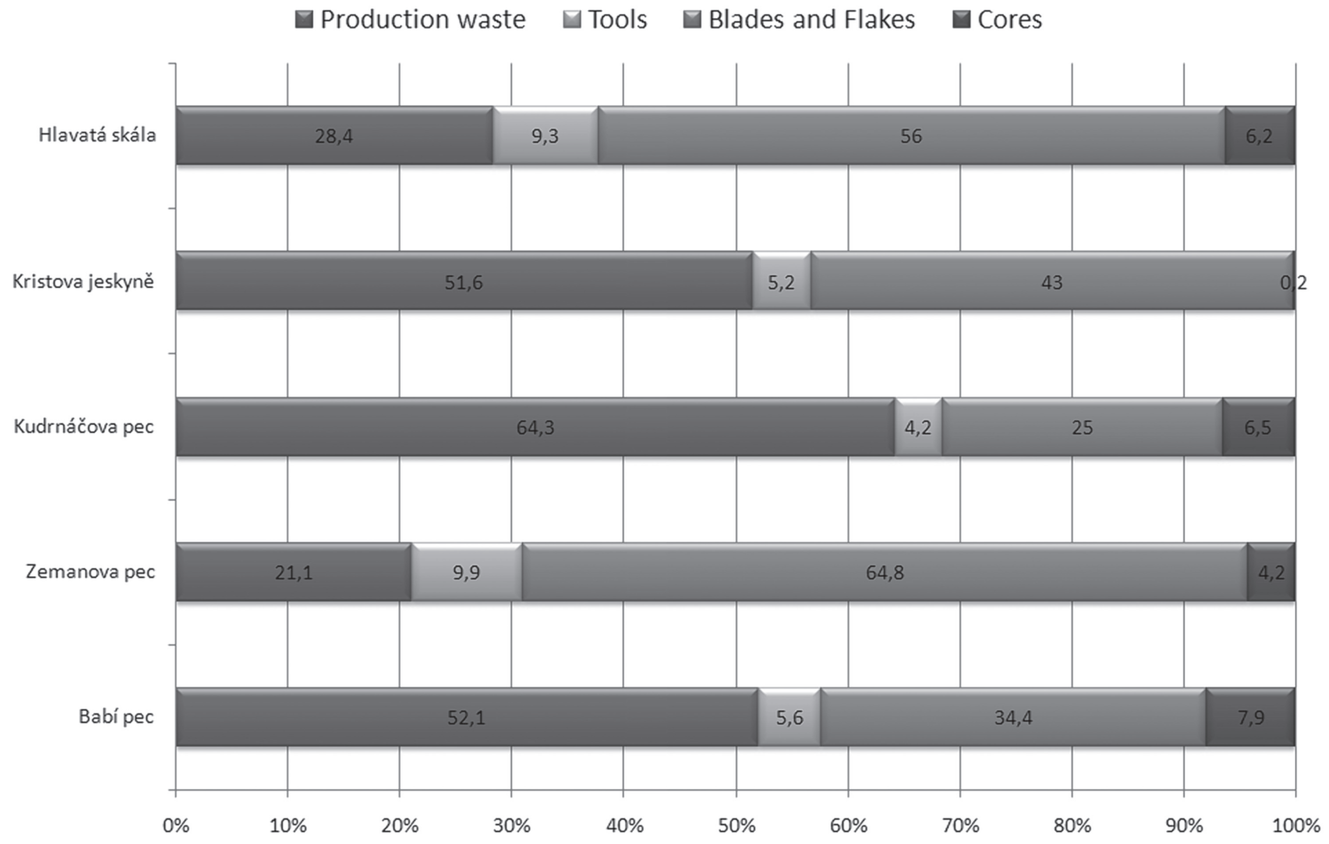

Figure 4.5. Technological groups of the chipped industries within Semily district.

exceed 4%. This includes quartzite of the Bečov and Tušimice type from north-west Bohemia, local quartzite of the Stvolínky type, and porcellanites. In contrast to Mesolithic settlement in Semily district, jasper is very rarely used as a raw material. Jasper was present from only one of the 27 sites studied, which is equivalent to 4% of the overall sample. On the other hand flint makes up 96% of the assemblages.

Outcrops and transport distances of lithic material in Česká Lípa and Děčín district

The location of lithic resources and their sources were described above, in relation to Semily district. However, some differences in transport distances are observed. Mesolithic sites in Česká Lípa and Děčín districts are located closer to sources of flints in the northern margin of Bohemia and, in case of Děčín district, directly in this area. In contrast, so called Kozákov minerals are located at a minimum of 30 km from Mesolithic settlements, while porcellanites from the Czech Cretaceous Basin are about 50–70 km away. Therefore, these minerals and rocks cannot be considered to be local raw materials, unlike the Mesolithic settlement within Semily district.

For Česká lípa district, quartzite of the Stvolínky type represents the specific local raw material available, but its use during the Mesolithic period is very rare, contributing a maximum of 15% towards raw material composition.

Technological composition of chipped stone industries from Česká Lípa and Děčín districts

Groups of chips and flake fragments, indicating production waste, are the most frequent categories in all of the assemblages. Their proportion varies from 37% to 85%, with a contribution of about 45–65% being most frequent. The proportion of semi-finished products (*i.e.* flakes and blades) varies mostly between 20% and 50% in individual assemblages. Generally, the number of retouched tools is quite small. Mostly these do not exceed 5%, with the maximum observed being 17%. In eight assemblages they are completely absent. Cores are represented in small number in all of the assemblages.

Conclusion

From the point of view of technological composition, there are no differences between Česká Lípa, Děčín and Semily district. The greatest part of the chipped stone industries is represented by production waste, followed by semi-finished products. The percentage of the tools in Semily district depends on the size of the assemblages. Generally, in smaller assemblages there are a greater number of tools (about 10% at Hlavatá skála and Zemanova pec). Cores are generally the smallest component of the assemblages.

In conclusion, the Mesolithic groups in Česká Lípa and Děčín district focused on the production of chipped stone industries from mostly locally available raw materials, such as flint or Stvolínky quartzite, which were generally available at distances of up to 10 km away. The main reason for this was not only the vicinity of the sources, but also, predominantly in the case of flint, their high quality and suitability for chipping. Raw materials from more distance sources, for example quartzite of the Tušimice and Bečov types or porcellanites, were used rarely as supplementary materials. Jasper and minerals generally originating from the surrounding region in Semily district were almost ignored. The higher proportions of local raw materials suggest a higher degree of stability within the settlements of Mesolithic groups from the regions studied.

Without question, chipped stone tools in the past, just as today, had a practical function. Mesolithic peoples modified the surrounding natural environment and made appropriate living conditions through their use. However, the formal characters of chipped stone tools are not only determined by human manual skills and social norms. The processes behind stone raw material selection are also a distinguishing factor, which is connected to knowledge of natural outcrops of different rocks and minerals, as well as their physical properties. In assemblages with the presence of raw materials transported from long distance, this possibly reflects a human effort to obtain technologically suitable production materials. The spread of some types of rocks and minerals from the area of their natural outcrops must have required or caused social contact between individuals and whole hunter-gatherer communities. The method of obtaining raw material indicates an intentional exchange or human transition through the landscape. Obtaining rock could be the primary motivation for a journey, or a secondary result of a hunting expedition.

The spatial framework in which the hunters existed can also be indirectly identified from raw materials in case of the Mesolithic settlers in Semily district. There was a stable model for obtaining the raw material, which is clearly dependent on the distance from which they came. Around one half of the lithic materials came from the immediate vicinity of archaeological sites, where primeval hunters exploited local minerals, primarily jasper, as well as opal-jasper, agate, jasper-agate, opal, chalcedony, crystal rocks and finally quartz. Green Cretaceous porcellanites were also present between local raw materials available up to 10 km from sites. The rest of the chipped stone industry was made from flint. The source of this raw material is a little further afield; about 10–30 km from the studied Mesolithic sites. The vectors for the origins of the observed raw materials tend to be to the north and north-west, where sporadically used high quality quartzite of the Bečov, Tušimice, and Skršín types originates. What is exceptional is the presence of Bavarian slab-like chert in the Babí pec assemblage, which implies indirect contact with the Upper Danube region and also the primeval hunters' outstanding orientation and knowledge of the landscape.

The narrow range of the area within which jasper was used (mainly Semily district) demonstrates a human connection (connection of one community) with this visually expressive red mineral. Movement of hunters and gatherers further pointed to the north and northwest of Czech Republic, where sources of drift flints lie. The acquisition of flints and their chipping was a common part of everyday life for Mesolithic people. This is supported by the high rate of drift flints in the composition of chipped stone industries (from 15 to 51%) and the length of transport distances observed. Distances of 10–30 kilometres can be traversed by foot without problems, usually during a single day. Sporadic use of quartzite of the Bečov and Tušimice type may reflect hunting trips to the northwest part of Bohemia, which took several days. Alternatively, this could represent peaceful contact with neighboring hunter-gatherers communities, who settled in the caves of today's Česká Lípa and Děčín districts, their stone tools made mostly from local drift flints and quartzite of the Stvolínky type, which is significant in this area. Use of these two rocks reflects a practical and symbolic aspect of raw material selection. Firstly, they were easily accessible and, mainly in the case of flint, easily chipped. They may also have served as a symbolic expression of a human community, in the case of the Stvolínky type quartzites. Quartzites from northwest Bohemia seems to be a suitable implement to tie up social relationships. The expressive formal features, such as colour, luster, and macroscopic structure, form the object of human focus.

The choice of certain raw materials, as well as movement through the landscape, was determined by the concrete practical, social, and ritual needs of Mesolithic people, or by their cultural norms. Stone raw material composition may reflect a human ability to deliberately create a purposeful tool with regards to the physical properties of the rock or mineral used, manufacturing technology, and material availability. In this case, it also serves to form an understanding of social links between communities and the ritual life of Mesolithic hunter-gatherers.

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5. Palaeoenvironments and Prehistoric Interactions in Northern France from the Eemian Interglacial to the End of the Weichselian Middle Pleniglacial

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Patrick Auguste, Clément Paris and David Hérisson

Abstract

The Upper Pleistocene in the north of France is characterised by discontinuous human presence, closely linked to climatic fluctuations. Human groups were mainly present during the Eemian interglacial and at the beginning of the Weichselian glacial period, as well as during the Late Glacial, in correlation with large mammal populations. Upper Pleistocene climatic fluctuations impacted on raw material access, which partly conditioned lithic production modalities. However, the influence of cultural traditions remains important, both for lithic production and subsistence strategies.

Introduction

The excavation of abundant Middle Palaeolithic sites over the past twenty years has provided invaluable chronological and environmental information on Upper Pleistocene human occupation in the north of France. This region is considered here to extend from the Seine to the Escaut Basins (Figure 5.1).

The study discussed in this paper is based on data from 47 excavated archaeological levels, representing a total surface area of about 55,952 m² (Table 5.1), combined with a unique frame of reference in Europe for Pleistocene sequences in loessic context. A total of 75,612 artefacts have been unearthed in these levels. From a chronological viewpoint, five of these levels are contemporary with the Eemian interglacial (Marine Isotope Stage 5e, see Table 5.1 and Figure 5.2), seven are attributed to MIS 5c, ten to MIS 5a and eight others, occurring in steppic soils, to the end of MIS 5a. Lastly, thirteen are contemporary with the end of the Lower Pleniglacial (MIS 4) or Middle Pleniglacial (MIS 3). This significant mass of information has enabled us to analyse interactions between climatic fluctuations, responsible for palaeoenvironmental modifications, and prehistoric occupations. Here we focus on four main themes: occupation density, raw materials, lithic industries and faunal remains.

Climatic changes and human occupations

During the Eemian, human occupations only appear to be preserved in fluviatile sediments (for example, at Caours – see Locht *et al*. 2010). At present, these are rare for taphonomic reasons (interglacial soil erosion from the first climatic deterioration at the beginning of the Glacial period onwards) (Locht 2004; Roebroeks and Speelers 2002), and do not expose a realistic record of the Neanderthal occupation of our regions during this interglacial (Figure 5.3). The climate and environment is comparable to that of the present temperate zone, with oceanic influence and deciduous woodlands. The forested landscape was closed, with abundant animal species represented by few specimens.

A slow climatic degradation and a progressive continentalisation of the climate in successive stages is observed from the beginning of the Weichselian glacial period (MIS 5d to 5a) (Antoine *et al*. 1994, 2003, 2011a, b). The faunal spectrum is less varied, but sizeable herds of herbivores were clearly present.

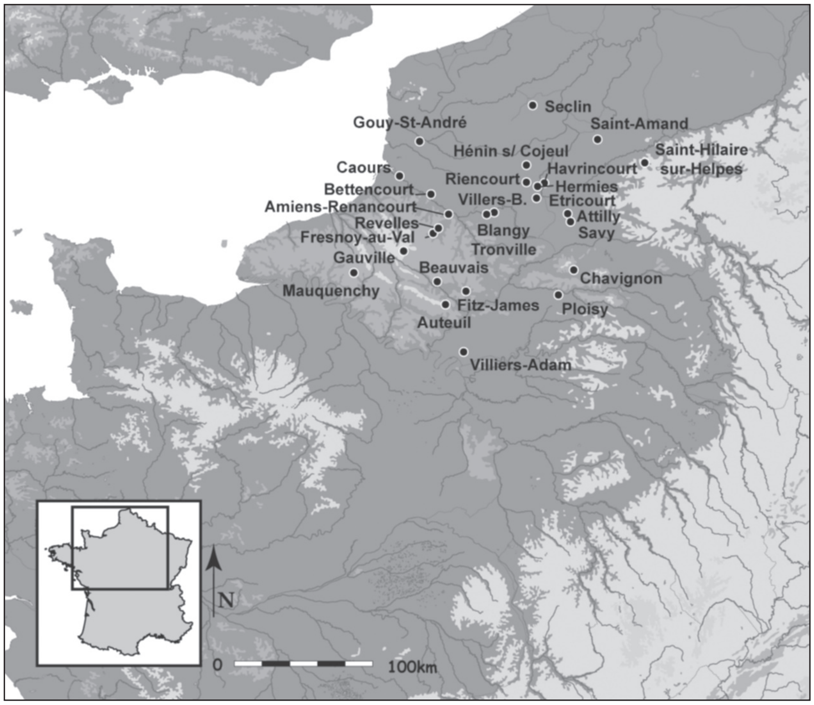

Figure 5.1. Location of the sites.

Sites are preserved in colluvial plateau sediments and especially on lower slopes where pedosedimentary activity is most developed. The high number of well-preserved sites due to favourable conditions seems to indicate that this type of environment was propitious to the implantation and subsistence of Middle Palaeolithic hunting groups.

During the Lower Weichselian glacial maximum (MIS 4), northern Europe seems to be abandoned by human populations. The recolonisation of these regions begins at the end of MIS 4 (Locht 2004) and continues during the Middle Pleniglacial (MIS 3). Again, sites are preserved in loess sediments on slopes and plateaus. The climate, environment and animal communities are globally characteristic of 'Mammoth steppe' conditions (Guthrie 1982), but human occupation appears to occur during short phases of climate improvement (interstadials), during which one can note the formation of Boreal brown soil type horizons. As there are fewer sites for this period than during the early glacial Weichselian, it is probable that human occupation was less dense at this time.

At the end of the Middle Pleniglacial, the first Early Upper Palaeolithic occupations appear in the north of France. Thus, the Havrincourt human occupations (Sector 2, Level 1: early Gravettian) and Amiens-Renancourt 2 in the suburbs of Amiens (early Gravettian) occur at about 28,500 BP (around 34 ka cal. BP), in a phase of relative climatic improvement during MIS 3 (Goval and Hérisson 2012; Paris *et al*. 2013).

Climate changes and raw materials

Apart from a few rare exceptions, the lithic series are made in Cretaceous flint issued from chalk, available throughout the region. Raw material access appeared difficult during the Eemian, given that temperate forests were abundant that must have concealed flint outcrops. Raw materials, therefore, must only have been accessible at tree falls or riverbeds. The five occupation levels at Caours indicate that flint blocks of reduced dimensions were collected from coarse alluvial deposits in the nearby Scardon. An identical situation occurred during the early Weichselian glacial, characterised by a continental environment with a Boreal forest and open herbaceous areas (Antoine *et al*. 1994). The abundant lithic series contemporary with this slow phase of climatic degradation (MIS 5d to 5a) also show that smaller blocks, gathered from broken stones on the plateau, were selected for reduction.

When the Lower Pleniglacial climatic deterioration eroded the chalky slopes, good-quality flint nodules of large size became available. This period corresponds to recurring Mousterian occupations at the base of these chalk taluses at the end of MIS 4 (for example Fitz-James, Teheux, 2001; Ault, Antoine and Auguste,

Site	Environment/stratigraphic position	Chronostratigraphy	MIS	Dating	Artefacts (no.)	Excavated Area (m²)	References
Caours N4	Calcareous fluvial silts (overbank)	Eemian interglacial	5e	121± 8 ka BP (TL heated flints, OSL)	1100	241	Antoine *et al.* 2006
Caours N3	Surface of peat layer (U9)	Eemian interglacial	5e		319	241	Antoine *et al.* 2006
Caours N2	Tufa deposit	Eemian interglacial	5e		132	241	Antoine *et al.* 2006
Caours N1	Tufa deposit	Eemian interglacial	5e	123 ± 3 (average / 10 U/Th TIMS dates from indurated tufa	221	241	Antoine *et al.* 2006
Caours N C	Tufa deposit	Eemian interglacial	5e		1374	115	Antoine *et al.* 2006
Saint-Sauveur	Organic calcareous fluvial silts	Weichselain Early-glacial A	5d (?)	95 ± 4 ka (U/th / bone / minimum age)	4	4	Antoine *et al.* 1995
Bettencourt N3b	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5d		1358	866	Locht (ed.) 2002
Bettencourt N3a	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5c		87	180	Locht (ed.) 2002
Fresnoy-au-Val 2	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5c	106.8 ± 7.5 ka BP (TL heated flints)	1313	1500	Goval et Locht, 2008
Villiers-Adam	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5c	110 ± 11 ka BP (TL heated flints)	2175	2830	Locht *et al.* 2003
Saint-Hilaire-sur-Helpe	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5c	98.9 ± 9.3 ka BP (TL heated flints)	119	2332	Lantoine and Feray 2006
Seclin D7	sandy organic fluvial silts	Weichselian Early-glacial A	5c	91 ± 11 (layer 4) ka to 95 ± 11 ka BP (layer 7,TL heated flints)	952	47	Tuffreau *et al.* 1994
Seclin D6	sandy organic fluvial silts	Weichselian Early-glacial A	5c	91 ± 11 ka to 95 ± 11 ka BP (TL heated flints)	704	39	Tuffreau *et al.* 1994
Revelles 'Le Camp Féron'	Bettencourt soil (grey forest soil)	Weichselian Early-glacial A	5c		62	752	Sellier-Ségard N. 2002
Mauquenchy, WA2	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a	83 ± 7.6 ka BP (TL heated flints)	80	3058	Locht *et al.* 2013
Fresnoy-au-Val 1	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		4240	1500	Goval and Locht 2008
Mauquenchy, WA1	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a	77 ka ± 7.2 ka (TL heated flints)	189	1223	Locht *et al.* 2013
Bettencourt N2b	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		6466	866	Locht (ed.) 2002.
Riencourt CA	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		5000	40	Tuffreau (ed.) 1993
Ploisy N1	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		33	388	Defaux 2004
Chavignon SGF	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		1164	5830	Sellier 2008
Hermies Champ Bruquette niv. H	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		4800	160	Vallin and Masson, 2004
Savy N3	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial A	5a		39	330	Locht *et al.* 2006
Etricourt HU	Saint Sauflieu SS1 soil (grey forest soil)	Weichselian Early-glacial B	5a		250	900	Hérisson *et al.* en cours
Bettencourt N1	Steppic soil (Saint-Sauflieu SS2 soil)	Weichselian Early-glacial B	5a final		438	866	Locht (ed.) 2002.

Auteuil sup.	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		1549	3700	Swinnen *et al.* 1996
Chavignon LBG	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		438	5830	Sellier 2008
Gouy St André	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		491	430	Depaepe and Deschodt 2001
Villers Bretonneux	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		79	262	Depaepe *et al.* 1997
Villers Bretonneux	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		102	262	Depaepe *et al.* 1997
Blangy-Tronville inf.	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		337	2000	Depaepe *et al.* 1999
Blangy-tronville sup.	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		92	2000	Depaepe *et al.* 1999
Ploisy N2	Steppic soil (Saint-Sauflieu SS2 / SS3)	Weichselian Early-glacial B	5a final		8	388	Defaux 2004
Beauvais 2	Eolian sands	Weichselian Lower Pleniglacial	4	55.6 ± 4 ka BP	11700	763	Locht 2004
Beauvais 1	Eolian sands	Weichselian Lower Pleniglacial	4		2000	763	Locht 2004
Fitz-James	Loess	Weichselian Lower Pleniglacial	4		1391	644	Guerlin 2001
Ault	Calcareous slope deposits (head)	Weichselian Lower Pleniglacial	4	55 ± 10 ka BP (RPE/U-Th bones)	-	-	Antoine and Auguste 2003
Savy N2	Brown loams	End isotopic stage 4/ beginning stage 3		48.7 + 8.2/-6.9 (TL sediments), 51 ± 3 ka (U-Th bones)	36	330	Locht *et al.* 2006
Havrincourt sect.1	Brown loams	End isotopic stage 4/ beginning stage 3		58 ± 7.2 (OSL)	73	2100	Goval *et al.* 2013
Havrincourt sect. 2, niv.2	Brown loams	End isotopic stage 4/ beginning stage 3		58 ± 7.2 (OSL)	88	4100	Goval *et al.* 2013
Attilly 2	base of Saint-Acheul boreal brown soil	Transition between Lower and Middle pleniglacials	4/3		74	73	Locht and Guerlin 1997
Attilly 1	Saint-Acheul boreal brown soil	Weichselian Middle Pleniglacial	3		452	292	Locht and Guerlin 1997
Hénin-sur-Cojeul G	Saint-Acheul boreal brown soil	Weichselian Middle Pleniglacial	3		3500	175	Marcy *et al.* 1993
Hermies T'chio Marché niv. Ic	Saint-Acheul boreal brown soil	Weichselian Middle Pleniglacial	3		790	30	Vallin and Masson 2004
Ploisy N3	Saint-Acheul boreal brown soil	Transition between Lower and Middle pleniglacials	4/3		286	388	Defaux 2004
Gauville	Saint-Acheul boreal brown soil	Weichselian Middle Pleniglacial	3		139	1555	Guerlin 2002
Saint-Amand-les-Eaux	Eolian sands	Weichselian Middle Pleniglacial	3	49.2 ± 3.34 ka BP (OSL)	11500	277	Feray *et al.* 2010
Havrincourt sect. 2, niv. 1	Arctic brown soil	Final part of Weichselian Middle Pleniglacial	3		6453	4100	Goval and Hérisson 2012
Amiens-Renancourt 2	Arctic brown soil	Final part of Weichselian Middle Pleniglacial	3		1415	700	Paris *et al.* 2013
				Total	75612	55952	

Table 5.1. List of concerned sites (fluvial sediments in grey).

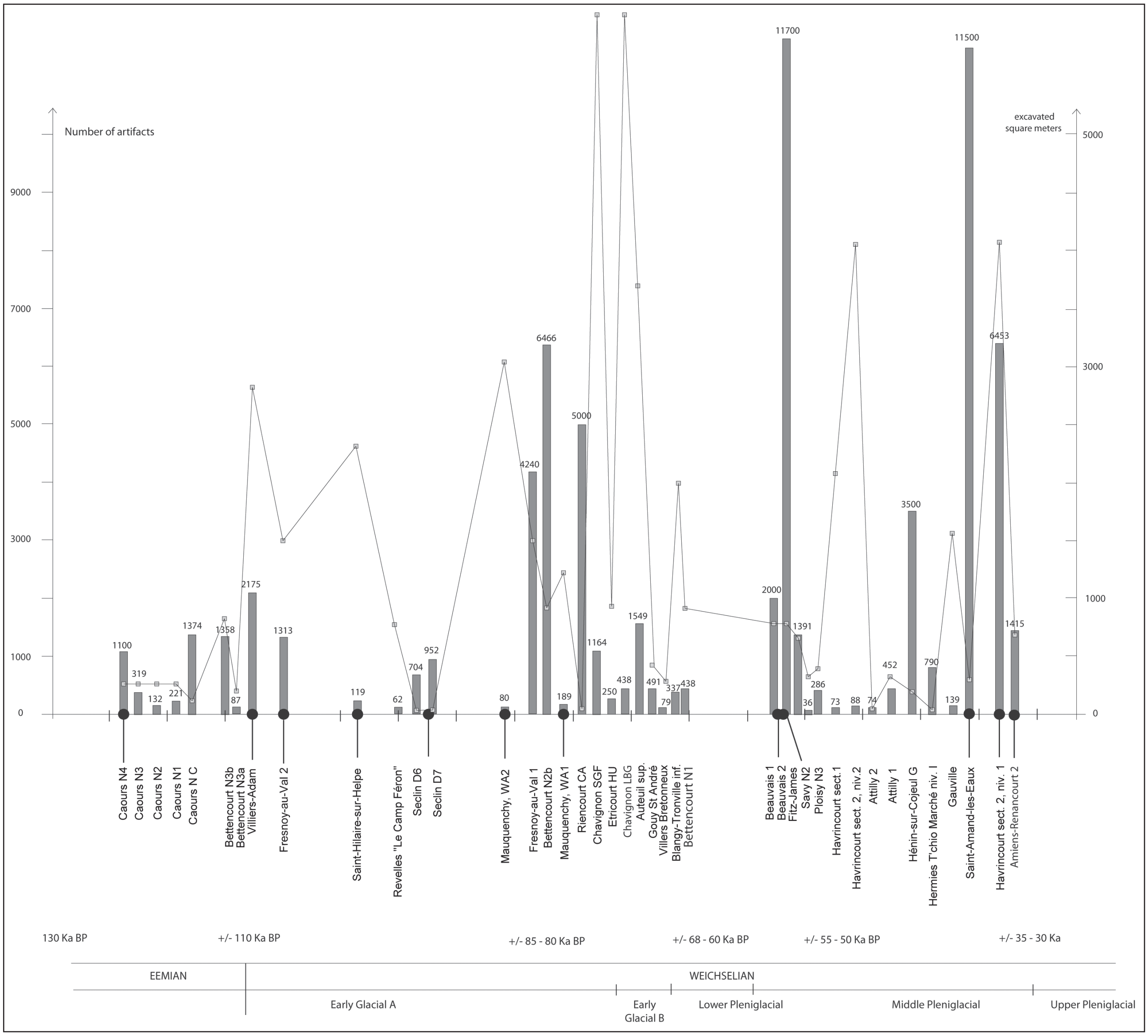

Figure 5.2. Excavated areas and number of artefacts.

2003, *etc*.). The less abundant lithic series from the Middle Pleniglacial (MIS 3) show that these outcrops must still have been partly accessible (Gauville, Attilly, Havrincourt Sector 1) before being covered with Upper Pleniglacial loess.

Climatic changes and lithic production systems

Environmental changes do not seem to have had a direct impact on lithic reduction strategies. During the Eemian, the five occupation levels from Caours indicate discoidal reduction, sometimes associated with Levallois methods (Figure 5.4). Subsequently, during the early Weichselian, reduction strategies became more diversified and several systems coexist (blade core, Levallois, convergent unipolar and sometimes discoidal) with multiple production aims (blades, flakes, points, *etc*.). At the end of the Lower Pleniglacial, raw materials became accessible once again and lithic complexes are characterized by the exclusive presence of Levallois debitage. The site of Beauvais is an exception with two levels characterised by the sole presence of discoidal debitage (Locht 2004). Handaxe production is very poorly represented, thereby emphasising the specialised nature of sites with handaxes and mass handaxe production (Figure 5.4).

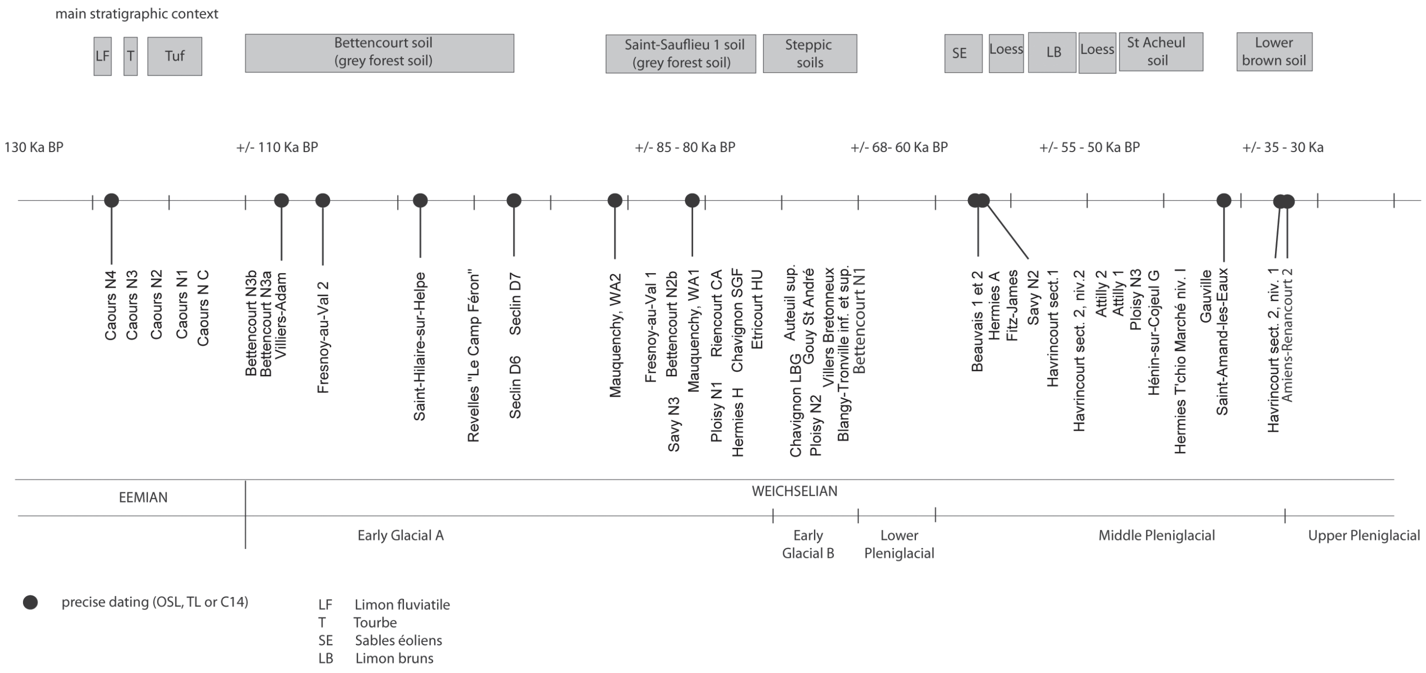

Figure 5.3. Chronostratigraphical position of the archaeological levels.

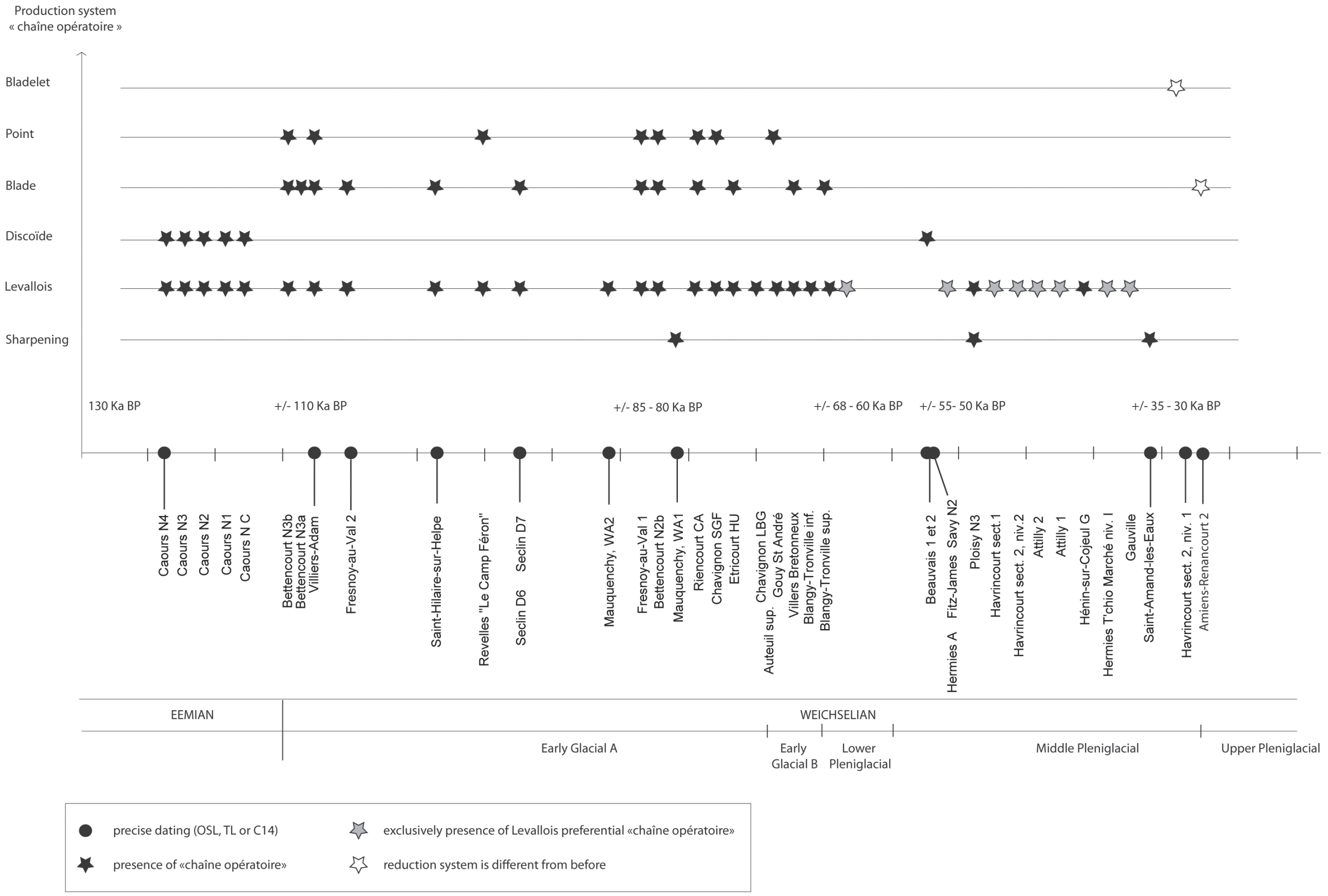

Figure 5.4. Characterisation of the main chaînes opératoires of the archaeological levels.

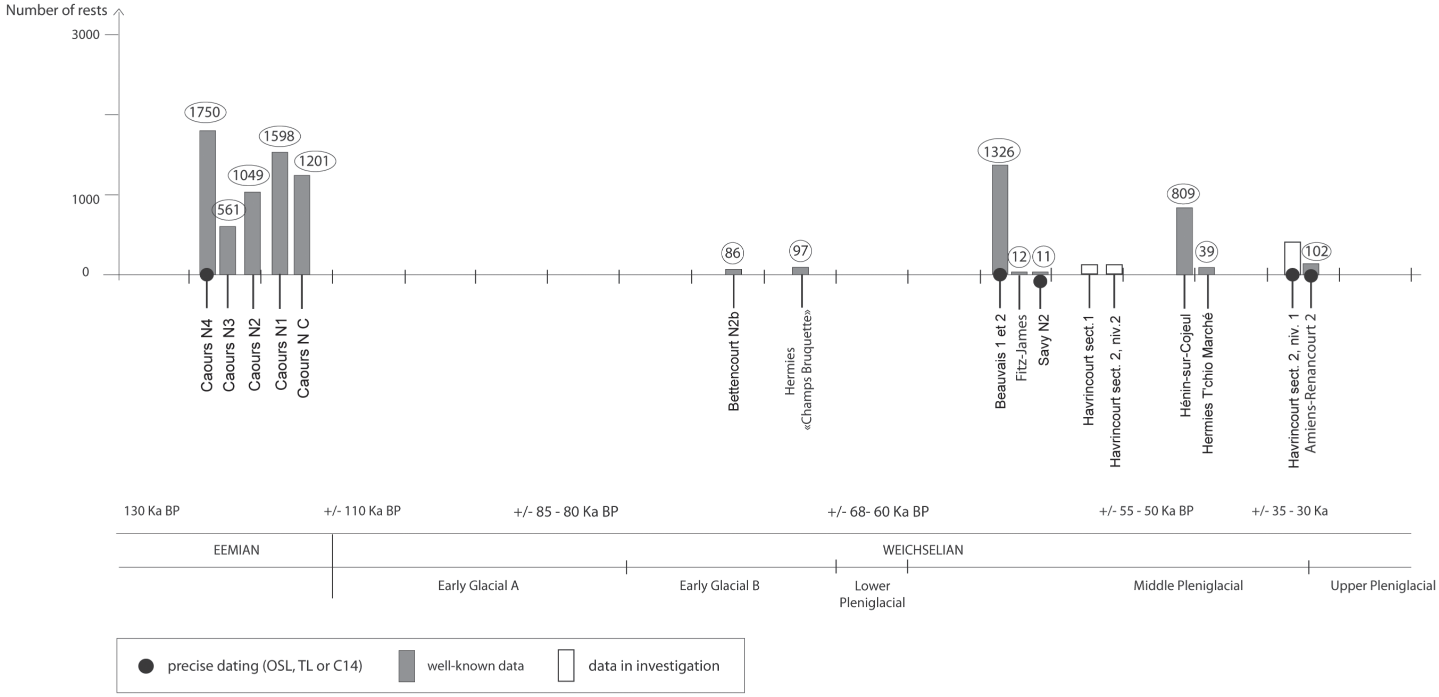

Figure 5.5. Number of preserved faunal remains.

The impact of climatic changes on subsistence strategies

Faunal data are less abundant, exclusively due to taphonomic reasons. Out of 47 occupations ascribed to the recent Middle Palaeolithic (MIS 5e to 3), only fourteen have yielded fauna (Figure 5.5). The two Early Upper Palaeolithic occupations (Havrincourt Sector 2, Level 1 and Renancourt 2) have also yielded abundant bone remains. During the Eemian, the fauna is dominated by cervids (red deer and fallow deer), but aurochs are also present, as shown by the five Caours levels. Generally speaking, the faunal series are then dominated by large herbivores from the beginning of the Weichselian glacial period, particularly horse and Steppe bison, like at Hermies or Hénin-sur-Cojeul (Auguste 2009). Woolly mammoth and woolly rhinoceros are also present, though much less abundant. However, mammoth plays a central role at certain sites, such as Ault. During phases of climatic deterioration, reindeer is present in the spectrum, *e.g.* at Beauvais and Havrincourt. All these occupations are mainly characterised by the hunting of large herbivores, although are occasionally oriented towards smaller animals such as reindeer. The butchery activities that have been identified at these sites attest to the removal of meat, occasionally accompanied by the breakage of long bones, indicating diversified subsistence strategies that may be linked to the seasonality of occupation. In all of the sites younger than the Eemian, the environment is always open and dominated by grasslands during clement phases, such as at Bettencourt-Saint-Ouen, and steppe during cold phases (Auguste 2012).

Discussion

Environmental changes had an impact on human access to flint, which was the main raw material during the Palaeolithic occupation of the north of France. Generally speaking, access to deposits was hampered by the presence of forests, which stimulated the procurement of flint from secondary sources. The flint nodules that were exploited are, therefore, relatively small in size and variable in quality. During the Lower Pleniglacial, slopes were eroded and flint bars became easily accessible on the chalky talus. Correspondingly, good-quality raw material was available in larger sized modules, propitious to the production of large preferential Levallois flakes.

Climatic change does not seem to have influenced the choice of lithic reduction strategies. The case of Bettencourt-Saint-Ouen is evocative and shows the persistence of similar needs (chaîne opératoires oriented towards the production of points, blades and flakes using identical technical schemas) for more than 40,000 years in the same area, across differing environments (forest at the base and steppe towards the top). This stability in lithic reduction strategies underlines the importance of cultural traditions in the face of environmental modifications (Locht 2002; Antoine *et al*. 2003). Recurring occupations at the northern French sites suggests some kind of management of territory, as well as the transmission of technical traditions throughout time.

Climatic modifications do not appear to influence Neanderthal subsistence strategies other than varying their main herbivorous prey taxa. Similar behaviour can be observed at sites characterised by contrasting environments, *e.g.* interglacial (Caours) and Pleniglacial (Beauvais) where subsistence strategies were identical. Hunting preferentially targeted small or medium sized herbivores, although larger species are present. Transportable animal carcasses, such as those of red deer, fallow deer, and reindeer, were brought back whole to butchery sites, while larger animals (*e.g.* elephant, aurochs, mammoth, and rhinoceros) seem to have been butchered at the kill site and brought back in quarters. At both sites, tools produced by discoidal reduction were mainly used for carcass processing. At other sites, however, large herbivores dominate, highlighting different subsistence strategies.

The occupations of both Neanderthals and the first anatomically humans in the north of France are correlated with phases of climatic amelioration. Both groups displayed the ability to adapt to their environment and their behaviour does not seem to have been very different. Thus, the animal and lithic procurement strategies demonstrate that subsistence behaviour and anticipation were similar during the Middle and Upper Palaeolithic (Locht 2004).

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6. The Feasibility of Reconstructing Neanderthal Demography as an Approach to Examining Extinction

Danae Rebecca Dodge

Introduction

The Neanderthal extinction is a contentious issue, which has led to extensive discussion of the factors that might be behind it. It may be possible to map Neanderthal population change through time to identify the impact that the extent of climatic deterioration and the arrival of anatomically modern humans had upon Neanderthal population decline and, therefore, their contribution to their extinction. However, this requires a high quality and quantity of genetic data. Despite new Neanderthal data being continually produced, genetic data is still relatively limited. This paper examines the requirements needed to enable a reconstruction of Neanderthal population change against a chronology. This will be done through the use of bison and spotted hyaenas (*Crocucta crocuta*) as proxies to identify weaknesses in the Neanderthal genetic data.

Issues affecting Neanderthal Extinction

The two factors commonly invoked as leading to Neanderthal extinction have been climate deterioration (Dansgaard *et al*., 1993; Finlayson *et al*., 2008; Golonova *et al*. 2010; Hublin and Roebrooks 2009; Sepulchre *et al*. 2007; Van Andel *et al*. 2003) and the arrival of anatomically modern humans (Banks *et al*. 2003; D'Errico and Sánchez-Goni 2003). There has been a distinct dichotomy between these factors, where often one is cited as the trigger at the exclusion of the other (Golonova *et al*. 2010; Lowe *et al*. 2012; Sepulchre *et al*. 2007).

The question of whether anatomically modern humans played a role in Neanderthal extinction is centred on the contemporaneity of radiocarbon dates. While it is important to bear in mind the limitations inherent in radiocarbon dating, as outlined by Pettitt and Pike (2001) and Higham (2011), radiocarbon dates do suggest contemporaneity between the two hominin species (Pettitt 1999) and there are studies that suggest levels of co-existence. Finlayson *et al*. (2006) discuss Neanderthals in refugia in Gibraltar with modern human presence 100 kilometres eastwards. Szmidt *et al*. (2010) find a chronological overlap between faunal remains from Aurignacian levels at Isturitz, France with those from Châtelperronian sites. Similarly, Longo *et al*. (2012) find an overlap in Northern Italy between dates from the Mousterian level at Riparro Mezzena, and the Proto-Aurignacian level at Grotta di Fumane. Several explanations have been proposed as leading to Neanderthal extinction via interactions with anatomically modern humans: warfare (Pettitt 1999), diseases brought by modern humans (Stringer *et al*. 2003), Neanderthal cannibalism (Underwood 2008), or a modern human advantage over Neanderthals, such as cognitive ability (Klein 2000), diet (Hockett 2012; Hockett and Haws 2005; Richards and Trinkaus 2009), which has been argued against (Hardy 2010; Stringer *et al*. 2008), and differences in weaning resulting in differential fertility (Pettitt 2000; Skinner 1997). Given the possibility of interbreeding between Neanderthals and modern humans (Green *et al*. 2010; Hammer 2011; Wall *et al*. 2009; Yotova *et al*. 2011) it is possible that modern humans subsumed the Neanderthal population. Nevertheless, this depends on the extent of interbreeding and requires further analyses to confirm/refute this theory (Alves *et al*. 2012; Durand *et al*. 2011; Eriksson and Manica 2012; Hodgson *et al*. 2010).

It is possible that both climatic deterioration and modern human presence affected the Neanderthal population, but the extent of this is unclear. One method that can be used to examine this is to reconstruct the Neanderthal demographic model alongside a chronology. This will allow a correlation between Neanderthal population change and particular dated events, thereby identifying how the climate and modern human arrival affected Neanderthals.

Neanderthal Genetic Review

Reconstructing Neanderthal demography requires a genetic dataset sufficient in both quality and quantity. The mitochondrial hypervariable region 1 (HVR1) within the control region is the gene for which there is the most genetic data available. Table 6.1 provides a summary of all the Neanderthal genetic data up to present, including several autosomal genes (Krause *et al*. 2007; Lalueza-Fox *et al*. 2007, 2008, 2009; Lopez-Valenzuela *et al*. 2012; Wang *et al*. 2012) and three Neanderthal draft genomes (including both mitochondrial and autosomal). As shown in Table 6.1, there are eighteen Neanderthal HVR1 DNA sequences (italicised). Only fourteen of these have radiocarbon dates (there were only twelve at the time of this study). The (DNA) sequence lengths vary considerably from 31 base pairs (bp) to the complete HVR1.

Reconstructing the demographic model

Various software programmes with suitable genetic and genealogical input, can reconstruct demographic models. BEAST (Bayesian Evolutionary Analysis of Sampling Trees) is one such programme, classified as Bayesian Markov Chain Monte Carlo (Drummond and Rambaut 2007). By altering the input parameters, BEAST tests various evolutionary hypotheses. The resultant output is a series of parameter values that best describes the evolutionary (genetic mutation/substitution) and demographic model (Dodge 2012). BEAST also creates the Bayesian Skyline plot (BSP) (Drummond *et al*. 2005) – the demographic model showing the effective population size (Ne) through time. The construction of the BSP is rooted in the coalescent principle (Kingman 1982), whereby there will be a time in the past when the individuals will share a common ancestor. The number of individuals sharing this common ancestor decreases further back in time reflecting a relationship between population size and individuals of shared ancestry (Griffiths and Tavaré 1994).

Using animals as proxies: Significance and data used

Using BEAST, Shapiro *et al*. (2004) and Drummond *et al*. (2003) were able to show how climatic effects affected bison population. The bison genetic dataset is large, with 191 sequences with various sequence lengths from 313 bp (Shapiro *et al*. 2004, Supplementary table S1, 8–18), making it an ideal candidate as a proxy to examine the minimal requirements of the BEAST programme. This will be done by systematically reducing the data for input into BEAST and removing data by clades.

White and Pettitt (2011) suggest hyaenas and Neanderthals share features that might make them sympatric, making hyaenas a suitable proxy for Neanderthal presence. Genetic data from British spotted hyaenas (Dodge *et al*. 2012) was added to data from the European mainland (Hofreiter *et al*. 2004; Rohland *et al*. 2005) (Table 6.2). Analysis of the cytochrome b gene enabled the British sequences to be placed within the tree (Figure 6.1). By partitioning the data, this can determine how geographical sampling affects the demographic model.

Goals and Objectives

Given the current limitations of the Neanderthal genetic data, the goal here is to identify what is required to allow for demographic reconstruction. Therefore, the objectives are to:

1) Identify the minimum quantitative and qualitative data requirements to enable demographic model reconstruction.
2) Determine how geographical sampling can affect the demographic model.
3) Assess how using an animal as a proxy can complement the Neanderthal demographic model to determine the extinction trigger(s).
4) Assess if a demographic model can be retrieved from a simulated Neanderthal dataset.

Examination of the bison dataset

Quantitative Analysis- Identifying the minimum quantitative and qualitative data requirements

Method

Ten sequences were randomly selected and removed from the data file before input into BEAST (*e.g.* 191 sequences, 181, 171 *etc*.) until 31 sequences remained in the input file, at which point one sequence was removed each time until 13 remained. For each output, the evolutionary parameter values were recorded (mutation rate, model *etc*.), and the BSPs were reconstructed. For each of the genetic parameter values, the cut-off point was identified. This is the point at which the confidence intervals (CI) dramatically increase, thereby decreasing the resolution to such an extreme degree that the values no longer reflect the initial model parameters (see Dodge 2012). The cut-off points identified for each parameter can then be coalesced into a single number to provide the minimum amount of sequences required that still enables an accurate demographic reconstruction.

Name	Location	Paper	DNA Region	Age of Specimen
Neanderthal 1	Feldhofer, Germany	Krings *et al.* 1997	Mitochondrial HVR1 (379 bp)	~ 40,000 BP
Neanderthal 1	Feldhofer, Germany	Krings *et al.* 1999	Mitochondrial HVR2 (345 bp)	40,000 BP
Vindija-75	Vindija, Croatia	Krings *et al.* 2000	Mitochondrial *HVR 1, 2 (357 bp)* (288 bp)	42,000 BP
Mezmaiskaya	Mezmaiskaya, N. Caucasus	Ovchinnikov 2000	Mitochondrial HVR 1 (345 bp)	29,195 BP
Neanderthal 2	Feldhofer, Germany	Schmitz *et al.* 2002	Mitochondrial HVR1 (357 bp)	~ 40,000 BP
Vindija-80	Croatia	Serre *et al.* 2004	Mitochondrial HVR1 (402 bp)	38,310 ±2130 BP
Vindija-77	Croatia		*(31 bp)*	Undated
Engis 2	Belgium		*(31 bp)*	"
Chapelle-aux-Saints	France		*(31 bp)*	"
El Sidron-441 (Tooth)	Spain	Lalueza-Fox *et al.* 2005	Mitochondrial HVR 1 (47 bp)	43,000 BP
Les Rochers-de-Villeneuve	France	Beauval *et al.* 2005	Mitochondrial HVR1 (31 bp)	40,700 BP
Monti Lessini	Italy	Caramelli *et al.* 2006	Mitochondrial HVR 1 (378 bp)	50,000 BP
Scladina	Belgium	Orlando *et al.* 2006	Mitochondrial HVR1 (123 bp)	100,00 BP
El-Sidron-1252 (Femur)	Spain	Lalueza-Fox *et al.* 2006	Mitochondrial HVR 1 (302 bp)	43,000 BP
Vindija-80	Croatia	Green *et al.* 2006	Of varying regions and lengths	38,310 ± 2130 BP
Vindija-80	Croatia	Noonan *et al.* 2006	1326 nuclear segments, varying lengths	38,310 ± 2130 BP
Teshik-Tash	Uzbekistan	Krause *et al.* 2007a	*HVR1 (190 bp)*	Not enough collagen
Okladinov	Altai, Siberia		*HVR1 (343 bp)*	29,990 ± 500–37,800 ± 400BP
El Sidron-1253	Spain	Krause *et al.* 2007b	Nuclear FOXP2	43,000 BP
El Sidron-1351c				
Vindija-80	Croatia	Briggs *et al.* 2007	Autosomal – varying regions and lengths	38,310 ± 2130 BP
Monti Lessini	Italy	Lalueza-Fox *et al.* 2007	Melanocortin 1 (89bp)	50,000 BP
Vindija-80	Croatia	Green *et al.* 2008	Mitochondrial Complete (16,565 bp)	38,310 ± 2130 BP
El Sidron-1253	Spain	Lalueza-Fox *et al.* 2008	ABO (blood) gene (7 exons of varying lengths)	43,000 BP
El Sidron-1351c				43,000 BP
Neanderthal 1	Feldhofer, Germany	Briggs *et al.* 2009	Mitochondrial Complete *(includes HVR1)* (16,565 bp)	~ 40,000 BP
Neanderthal 2	Feldhofer, Germany			"
Mezmaiskaya	N. Caucasus			29,195 BP
Vindija-77	Croatia			Undated
El-Sidron-1253	Spain			43,000 BP
El Sidron-1253	Spain	Lalueza-Fox *et al.* 2009	TAS2R38 (1002 bp)	43,000 BP
Vindija-80 (33.16)	Croatia	Green *et al.* 2010	Mitochondrial complete (HVR1)	38,310 ± 2130 BP
Vindija-77 (33.25)	Croatia		+ autosomal varying regions and lengths (includes amelotin)	Undated
Vindija-33.26	Croatia			44,450 ± 550 BP
El Sidron-1253	Spain	Burbano *et al.* 2010	Protein codin regions on various chromosomes	43,000 BP
Valdegoba	Spain	Dalen *et al.*2012	Mitochondrial control region *(includes HVR1)*	48,500 BP
Monte Lessini	Italy	Wang *et al.* 2012	Immune SIGLIC17 (62 bp)	50,000 BP
El Sidron	Spain	Lopez-Valenzuela *et al.* 2012	Amelotin (protein involved in teeth formation) 72bp	43,000 BP

Table 6.1, Summary table of all Neanderthal genetic analyses to date. HVR1 samples are in italic.

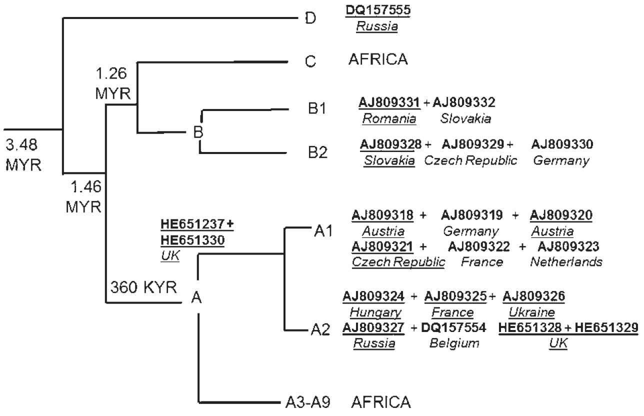
D
DQ157555
Russia
C
AFRICA
1.26
MYR
B1
AJ809331 + AJ809332
Romania Slovakia
B
B2
AJ809328 + AJ809329 + AJ809330
Slovakia Czech Republic Germany
3.48
MYR
1.46
MYR
HE651237 +
HE651330
UK
A1
AJ809318 + AJ809319 + AJ809320
Austria Germany Austria
AJ809321 + AJ809322 + AJ809323
Czech Republic France Netherlands
360 KYR
A
AJ809324 + AJ809325 + AJ809326
Hungary France Ukraine
A2
AJ809327 + DQ157554 HE651328 + HE651329
Russia Belgium UK
A3-A9
AFRICA

Figure 6.1. Spotted hyaena tree displaying the clades and which of the genetic sequences (with their accession numbers) from Rohland et al. *(2005), Hofreiter* et al. *(2004) and Dodge* et al. *(2012) belong to which clade, using the mitochondrial cytochrome b gene. Underlined samples are those that have radiocarbon dates. The dates indicate the times to the most recent common ancestor. Clade C and A3–A9 show modern day African hyaena populations, while the remainder are Pleistocene spotted hyaenas.*

Results

The results indicate that no less than 31 sequences should be used as the minimum data requirement for the evolutionary parameters (Dodge 2012). In the BSPs, the resolution of the population signal, as indicated by the CI, diminished when 51 sequences remained in the input file. This lack of resolution is reflected in the mean Ne at the mode of the time to most recent common ancestor (tMRCA), as shown by Dodge (2012, figure 11). It is clear there is a significant increase in the CI from 51 sequences in the input file to 41 sequences remaining in the input file.

Discussion

Dodge (2012) discusses several essential factors when interpreting the results. The first is the substitution rate, which provides the calibration. Substitution rates vary between genes and different species, due to gene conservation and inherited factors respectively (Ho 2009). There has also been considerable debate regarding the time dependency of the mutation rate on the age of the DNA sequences (Emerson 2007; Ho *et al*. 2005). The time dependency model posits that within one gene of one species, the age of the sequence can affect the estimated substitution rate. Further analyses, however,

Location	Age (BP)/Lab No.	Accession No.	Reference
Teufelslucke, Austria	38060 VERA-2536	AJ809318	Hofreiter *et al.* 2004
Irpfel 4, Germany	Unknown	AJ809319	"
Winden, Austria	38680 (+970/-870) VERA-2538	AJ809320	"
Vypustek p, Czech Republic	46000 (+2400/-1820) VERA-2531	AJ809321	"
PLU 681 E3 II Les Plummetes, France	Unknown	AJ809322	"
North Sea, Netherlands	Unknown	AJ809323	"
Igric (V10529), Hungary	41800 (+1400/-1200) VERA-2534	AJ809324	"
RDV 01H1023 Les Roches-de-Villeneuve, France	40,700 ± 900 BETA-177765	AJ809325	"
Bukovinka, Ukraine	41300 (+1,300/-1,100) VERA-2529	AJ809326	"
Denisova Cave, Altai, Russia	42, 300 (+940/-840) KIA-25284	AJ809327	"
Certova 1, Slovakia	51200 (+4900/-1,100) VERA-2530	AJ809328	"
Sveduv 2, Czech Republic	Unknown	AJ809329	"
Linde 1, Lindenthal, Germany	Unknown	AJ809330	"
Kiske p4 (V14484), Romenia	>48,500 VERA-2535	AJ809331	"
TS 250, Tmava, Slovakia	Unknown	AJ809332	"
28 12 37, Goyet Cave, Belgium	Unknown	DQ157554	Rohland *et al.* 2005
895 34490 1, Russia	48650 (+2380/-1840) KIA-25285	DQ157555	"
HY1 Creswell Crags, UK	OxA-X-2352-10	HE651327	Dodge *et al.* 2012
HY2 Creswell Crags, UK	OxA-21995	HE651328	"
HY3 Creswell Crags, UK	OxA21996	HE651329	"
HY5 Creswell Crags, UK	OxA-21997	HE651330	"

Table 6.2. Summary table of all Pleistocene spotted hyaena analyses to date.

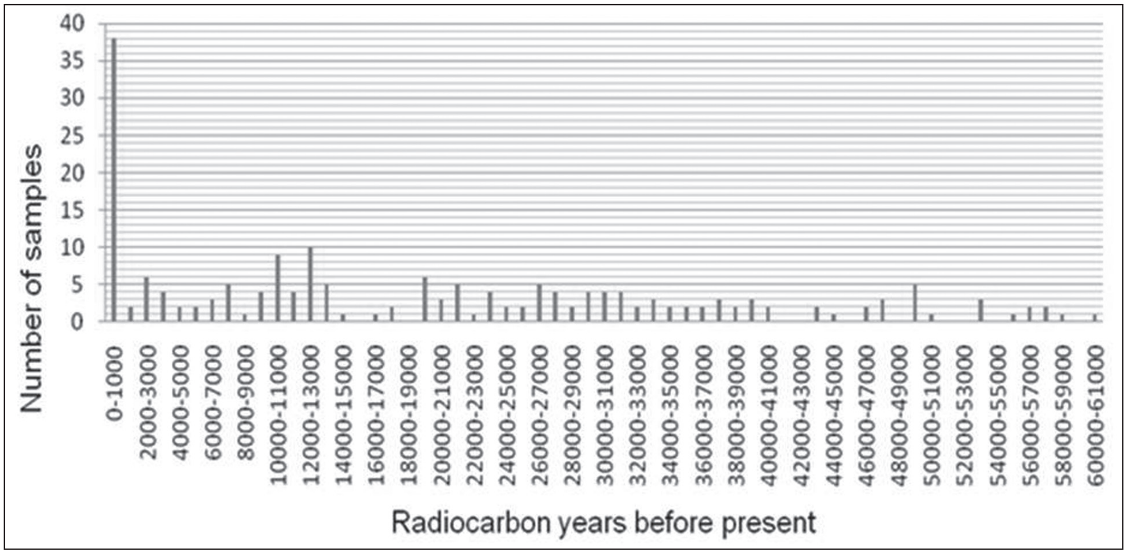

Figure 6.2. Age distribution of radiocarbon dated samples in bins of 1000 for the bison molecular data used in this study.

revealed that over-estimation of the substitution rate was largely due to sequences containing low genetic information and inaccurate prior parameters (Debruyne and Poinar 2009; Ho *et al*. 2007), which would currently mean that the Neanderthal data would yield erroneous evolutionary genetic parameter results.

Secondly, the change in parameter values as the data is reduced reflects how the information content is reduced; as the data is removed, so is the genetic variation. Consequently, the parameter values are specific only to the bison dataset, requiring that the results be viewed more as a guideline. While the bison results do not give an exact number of Neanderthal sequences to be input into BEAST, they do provide a minimum number: If the quantity and quality of the bison data means no less than 31 sequences should be used, the same can be said for a dataset that equals the quantity and quality of the bison sequences. Given the low quantity and quality of the Neanderthal data, no less than 31 Neanderthal sequences should be used.

The third factor regards the BSP. Because the coalescent principle is fundamentally rooted in the BSP construction (Drummond *et al*. 2002, 2005) any DNA damage could be mistakenly interpreted as false diversity. This can lead to erroneous calculations of the DNA substitution rate and/or the illusion of a more diverse species or node (Axelsson *et al*. 2008). Furthermore, false diversity can lead to an inaccurate tMRCA, which will impair the BSP.

Finally, just as with the genetic parameters, the removal of samples can affect the population signal due to the sample age distribution. Therefore, it becomes important to ensure that enough samples are used that span a range of dates. The full bison dataset, as shown in Figure 6.2, has a relatively uniform age distribution with at least one sample in every bin of 1,000 years, with a few exceptions, thus allowing for a population signal to be identified.

This discussion highlights the importance of obtaining good quality DNA to ensure accurate and valid evolutionary and demographic parameters.

Clade removal- Determining how geographical sampling can affect the demographic model

Method

The bison data consisted of four clades: Siberian (15 sequences), South of Ice (31 sequences), Eastern Beringia (106 sequences), and Edmonton (39 sequences) (Shapiro *et al*. 2004, Supplementary table S1, 8–18). This meant that removing a clade and comparing the parameter results here to the Quantitative Analysis results (where the input data between the Clade Removal and Quantitative Analysis is roughly equal) could test how geographical sampling affected the data. For example, removing the Siberian clade (15 sequences) left 176 sequences in the input file. This was compared to the Quantitative Analysis results of 171 sequences remaining in the input file. The same was done for the remaining data, so the data that had the South of Ice clade removed was compared with 161 sequences remaining in the input file from the Quantitative Analysis. The Eastern Beringia clade removal data was compared with 81 sequences remaining and the Edmonton clade removal data was compared with

	171 + Siberia	161 + S. of Ice	151 + Edmonton	81 + E. Beringia
Posterior	p>0.05	p=0.01-0.001**	p≤0.001***	p≤0.001***
Age of Root	p>0.05	p>0.05	p>0.05	p>0.05
Mutation Rate	p>0.05	p>0.05	p>0.05	p>0.05
Kappa	p>0.05	p>0.05	p>0.05	p>0.05
Shape	p>0.05	p>0.05	p>0.05	p>0.05
pINV	p>0.05	p>0.05	p>0.05	p>0.05

*Table 6.3. Summary table showing the results of the significant tests between the Quantitative Analysis and Clade Removal. The posterior is the (normalised) product of the likelihood that the model fits the data. The age of root is the time to most recent common ancestor, while the mutation rate, kappa, shape parameter and the pINV (proportion of invariant sites) are characteristics of the DNA mutation model. See Strimmer and von Haessler (2003) for definitions of each genetic parameter and how they describe the mutation model. In this table, p>0.05 means not significant, p= 0.01–0.001** means significant and p≤0.001*** means highly significant.*

151 sequences remaining. Significance testing using 'R' (R Foundation for Statistical Computing, 2001) was carried out on the genetic parameter values between the pairs. The result was expressed as a p-value where if p>0.05 then the result is not significant and removing the aforesaid clade made no difference to the genetic parameter being tested.

Results

The general trend for all the evolutionary genetic parameters is no significance, as Table 6.3 shows. This indicates that removing a clade does not affect the results. The only parameter that is significant is the posterior. The posterior parameter is the normalised product of the likelihood that the model (*i.e.* evolutionary parameters and the tree) fit with the input prior data. This value reflects that the more data there is available, the more likely it is that the final model will be accurate. The pair of data that have the most input data in the file is 171 sequences with the Siberian clade removed. With most data remaining in the file after the Siberian clade is removed, there is no difference to the results when compared to the Quantitative Analysis (171) results: there is no significance (p>0.05). Therefore, removing a clade with few sequences as compared to removing data randomly (also of a few sequences) leads to similar results. However, as the data in the input file becomes less it appears that removing a clade does make a difference to the results. For example, p≤0.001 for 81 sequences with the Eastern Beringia clade removed. This suggests that geographical sampling does affect the evolutionary model, but only when the input data is already limited. In this case, the results start to become significant when the South of Ice clade is removed (31 sequences), which is less than 17% of the data. Selectively analysing parts of the data should be avoided if the data is already limited in quantity and quality. This could potentially reduce the resolution in the BSP.

Hyaena (Crocuta crocuta) analysis as a supplementary approach

Using hyaenas as a proxy to complement the Neanderthal demographic model

Archaeology and genetic analysis of the mitochondrial cytochrome b gene indicates three dispersal events of the spotted hyaena from Africa. Two of these reached Britain, the first prior to 700,000 (kyr) BP and the second after 360 kyr BP (Dodge *et al*. 2012; Hofreiter *et al*. 2004; Rohland *et al*. 2005). Genetic results from Dodge *et al*. (2012) support Turner's (2009) theory of local extinction during the Ipswichian, and a second migration of hyaenas during the Devensian before their extinction around 30 kyr BP. Similar features in migration, distribution, and niche imply that hyaenas could be used as a proxy to infer Neanderthal migration and distribution. It is quite possible that hyaenas were drawn towards Neanderthal settlements just as modern hyaenas are drawn towards modern African settlements for scavenging opportunities (Kruuk 1972). This makes it likely that hyaenas were part of a suite of species that followed hominins as they migrated from Africa (Turner 1994). It may be possible to identify common environmental triggers from a hyaena demographic reconstruction that results in population decline and extinction in both Neanderthals and hyaenas. However, a later study refuted the idea that hominins were followed by a suite of species. O'Regan *et al*. (2011) examined large scale dispersals of species (including hyaenas) from Africa into other continents. The results suggested that, because of different environmental tolerances, species migrated of their own accord rather than following hominins. Lorenzen *et al*. (2011) identified a similar trend in the mega-fauna herbivores of Eurasia and North America, revealing that each species responded differently to an array of environmental triggers. These studies suggest that using animals as proxies may not be entirely plausible on a continental scale and that it may not be possible to identify common environmental triggers between hyaenas and Neanderthals. Nevertheless, similarities between them warrants further analysis of the potential to use hyaenas as a proxy to map distribution and migration regionally.

Hyaena data analysis in BEAST: determining how geographical sampling can affect the demographic model

Method

There were fourteen radiocarbon dated sequences, ten from the mainland and four from Britain, enabling data to be partitioned into four datasets for BEAST input: 'All sequences with tree prior', 'All sequences without tree prior', 'Continental sequences with tree prior', 'Continental sequences without tree prior' (where the tree prior refers to Figure 6.1). The input file for BEAST was adapted from Ho *et al*. (2007). By pairing the datasets appropriately, the following questions could be asked by conducting significance tests on the genetic parameter results between the pairs: 1) does the inclusion of the tree prior make a difference? 2) To what extent does omitting the British DNA sequences affect the results?

Results

Significance testing of all the pairs of data displayed no significance; *i.e.* inclusion of the tree prior or the British hyaena data did not make a difference. These results are a direct symptom of a large genetic parameter CI due to limited data, which is supported by the bison results. Where data is extremely limited, such partitioning for clade analyses will not yield accurate evolutionary parameters and a suitable BSP.

Neanderthal-Simulated data: can a demographic model be retrieved?

Method

DNA was simulated using Bayesian Serial Simcoal (BayeSSC) (Excoffier *et al*. 2000) to appear to be Neanderthal data. Sixty-two sequences were simulated at specifically dated times, and Briggs *et al*.'s (2009) substitution model was used to create a hypothetical HVR1 region, which was 278 bp long (the average length calculated from the twelve Neanderthal sequences that have dates and sequence lengths longer than 100 bp). Of the sixty-two sequences, twelve were specifically simulated at the time point where the twelve Neanderthal sequences have been dated at; the oldest at 100 kyr BP from Scladina (Orlando *et al*., 2006) to the youngest at 29.2 kyr BP from Mezmaiskaya (Ovchinnikov, 2000). This provided 2833 generations. The remaining fifty sequences were simulated between these time points, the frequency of which increases as time passes towards the youngest generation. This was to give the appearance of an aDNA dataset where younger samples were most likely to yield aDNA, assuming all other environmental conditions are equal. Sequences were simulated under two different demographic models – Crash and Decline – using the demographic priors from Fabre *et al*. (2009). The 'Crash' model postulates an initial Ne of 11,000 individuals at 100 kyr BP (generation 2832) remaining constant until 45,175 years BP (generation 640), whereupon the population declines to extinction; an Ne of two individuals at time 29,200 (generation 0). For the 'Decline' model, the Ne starts at 25,000 at generation 3102. The number of generations was extended so as to allow for sufficient Ne at the specific times when sequences are simulated. The population size was allowed to reduce at a steady rate until extinction at generation 0.

After simulation, half of the datasets from both of the models were randomly selected for BEAST input, as was the full 'Decline' model dataset. The same substitution model and demographic priors used for simulating were input into BEAST. The chain length, stating how long BEAST runs for and how many times the parameter values change, was set at 10 million iterations, where sampling occurred at every 20,000 iterations. Two further analyses were conducted on the 'Decline' halved data: one where the chain length was set at 20 million iterations, with sampling at every 20,000, and the other also set at 20 million iterations, but this time sampled at every 5,000. Additionally, for the full dataset the chain length remained at 20 million sampling at every 5,000.

Results

Tables 6.4 to 6.6 show the results of the age of root and the substitution rate of the three datasets. The age of root estimates here are very young and the corresponding CI are extremely small given the oldest sampled sequence is dated at 100 kyr BP. Due to the coalescent (Drummond and Rambaut 2007), this will adversely affect demographic model recovery as the BSP starts with Ne at the age of root estimate and not the actual age of root. Basu and Majumder (2003)

	Bayesian prior		
	Lower	*Mean*	*Upper*
Age of root (years BP)	16,010	16,090	16,350
Mean (ln) posterior		-617.807	
Mutation rate (subst./site/yr)	1.128E-06	2.312E-06	3.855E-06

Table 6.4. Results from the Bayesian analyses on the thirty-one simulated sequences from the Crash model. The age of root estimate is measured as years before present (BP) and the mutation rate is measured as substitutions per site per year. The chain length was set at 10 million iterations, with sampling every 20,000 iterations.

	Bayesian prior		
	Lower	*Mean*	*Upper*
Age of root (years BP)	16,810	17,200	18,300
Mean (ln) posterior		-562.705	
Mutation rate (subst./site/yr)	-562.705	1.7E-07	5.307E-07

Table 6.5. Results from the Bayesian analyses on the thirty-one simulated sequences from the Decline model. The age of root estimate is measured as years before present (BP) and the mutation rate is measured as substitutions per site per year. The chain length was set at 10 million iterations, with sampling every 20,000 iterations.

	Bayesian prior		
	Lower	*Mean*	*Upper*
Age of root (years BP)	70,810	71,170	72,230
Mean (ln) posterior		-740.29	
Mutation rate (subst./site/yr)	1.278E-12	4.511E-08	1.377E-07

Table 6.6. Results from the Bayesian analyses on the complete simulated sequences from the Decline model. The age of root estimate is measured as years before present (BP) and the mutation rate is measured as substitutions per site per year. The chain length was set at 20 million and the frequency of sampling was every 5000 iterations.

identified factors that can result in severe age of root under-estimation: long sequence length (500+ bp), long evolutionary times (>500 generations), high mutation rates (mutation rate>10–5) and various population sizes used as prior information. For both models used here the sequence length was 278 bp, eliminating the effect of sequence length. The generation time could have affected the under-estimation, as in both models it was considerably longer than 500. In both sets of results, the mutation rate was low, although in the 'Crash' results the CI were small, while for the 'Decline' results the CI was large. It is likely that the wide CI is enabling an increase in the mean mutation rate. Consequently, given the possibility of the time-dependency model, the age of root will decrease, resulting in severe age of root under-estimation. Against the time-dependency model, Emerson (2007) suggests it is the associated dates of sequences that results in over-estimation of the rates and under-estimation of the age of root. Navascués and Emerson (2009) suggest the phylogenetic tree as prior information could also lead to inaccurate rate estimates. If aDNA sequences are being sampled from one clade that is reciprocally monophyletic, this could lead to increased rates. They also found that a demographic model that is too complex can affect rate estimates. For example, a strong bottleneck had a more negative affect on rate estimation. A more complex demographic model used as prior information can result in a phylogeny that is considerably different from the actual one. This occurs because the resulting phylogeny (used for the demographic reconstruction) is the one that has the highest likelihood, even though it may not necessarily be the most accurate (*ibid.*). This can therefore lead to age of root under-estimation additionally distorting mutation rates. The effective sample sizes (ESS) also supports that the complexity of the demographic model could affect the mutation rate and the age of root. The ESS is a measure of independent sampling, reflecting the extent of sampling where a value of <100 indicates that it is insufficient. In the case of the 'Decline' model, the values for the mean posterior, prior and skyline (Drummond and Rambaut 2007), and the ESS values were much lower than the recommended value of 100. To increase the ESS, further analyses were carried out by extending the chain length and sampling. Nevertheless, the values for those parameters did not increase sufficiently. With low ESS values, the 'Decline' model results cannot be included. The 'Crash' results did produce sufficient ESS values. This suggests that a difference in the prior demographic model could be affecting the parameter sampling and, therefore, the discrepancy in mutation rates and age of root.

It is clear that several factors are preventing a demographic model from being achieved. The final evolutionary parameters show it is the input information that is largely affecting the results; demographic priors and good quality DNA data.

Discussion

Establishing a set of criteria for genetic data

Three themes run concurrently in these results, highlighting their importance as criteria to consider that the genetic data must adhere to for demographic model reconstruction. The first is archaeological considerations; *i.e.* obtaining good quality DNA. DNA damage affects the results, producing false diversity and short sequence lengths, resulting in erroneous parameters, such as mutation rate, age of root, and invalid BSP. From all analyses, the second criterion is the importance of sampling across all time periods, geographic regions, and clades within a known phylogenetic tree. In addition, it must be ensured that samples are sufficient in quantity and have selected an appropriate gene. This has implications for the final criterion, which are Bayesian considerations. These concern the information that is known about a gene to input as a prior. Such information includes the mutation rate and the phylogenetic tree, which is dependent upon the gene that is sampled. Finally, it is important that complex demographic models be accounted for in order to input appropriate priors.

Application of criterion to the Neanderthal data

Archaeological Considerations

Despite technological advances, three issues still hinder the retrieval of good quality DNA: genome coverage (for the Neanderthal genome there is <2%), possibility of contamination by modern humans, and DNA degradation, which occurs post-mortem (Hofreiter *et al*. 2004; Pääbo *et al*. 2004). This study indicates that DNA degradation is the primary factor influencing the final results. Factors affecting the rate of degradation include age of the material, burial context (Eglinton *et al*. 1991), and environmental conditions, such as temperature (Smith *et al*. 2001) and pH (Pruvost *et al*. 2007). The biochemical damage incurred leads to nucleotide mis-incorporations and modified bases predisposing DNA to fragment, resulting in short sequence lengths (Pääbo *et al*. 2004). Models of DNA degradation can be incorporated into analyses as more is learnt. Before the introduction of high-throughput sequencing, Neanderthal genetic data was limited to mitochondrial DNA. The development of sequencing technology (Margulies *et al*. 2005) has led to a vast increase in the amount of Neanderthal genetic data available for use (Green *et al*. 2006, 2010; Noonan *et al*. 2006), including autosomal genes. The discovery of a new hominin species (Denisovans) (Krause *et al*. 2010; Reich *et al*. 2010) means that Neanderthal genetic data can be analysed in this context, providing more detail on Neanderthal evolutionary and phylogenetic history. Prevention of DNA contamination is an issue that starts at excavation (Brown 1998; Fortea *et al*. 2008; Pruvost *et al*. 2007) that can later be assessed (Green *et al*. 2010; Meyer *et al*. 2012), and a recent development in sequencing has enabled high coverage of ancient genomes to be obtained (Meyer *et al*. 2012).

Importance of Sampling

Bearing these archaeological considerations in mind, it is clear why the age distribution of the Neanderthal samples is not uniform (Figure 6.3). Enough samples need to be selected across a large geographical area that fall within the time range 60–100 kyr BP. If an additional five DNA samples (of sufficient quality and length) were in every bin (organised into every 5,000 years), this would yield a total of forty Neanderthal samples, which, when added to the current fourteen, provides fifty-four sequences – more than the bison minimum sequences required by BEAST to potentially provide a genetic dataset suitable for demographic analysis.

The accuracy of sample dates is important for calibration (Debruyne and Poinar 2009). However, when considering the time range for which samples need to be dated to and given the limits for radiocarbon dating, obtaining samples for the time period 60 kyr BP and beyond proves problematic. In this case, other dating methods need to be employed, such as thermoluminescence and electron spin resonance (Dreimanis *et al*. 1978; Grün and Stringer 1991). Dates

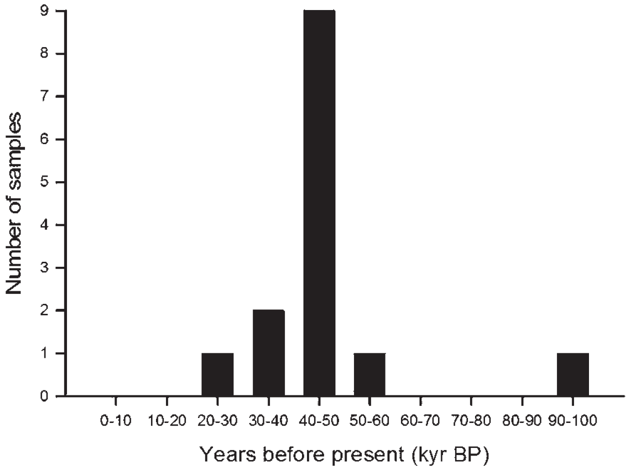

Figure 6.3. Age distribution of the dated Neanderthal samples that have had their mitochondrial HVR1 analysed. See Table 1 for details. The bar graph depicts the samples in bins of 10,000 years.

near the 25 kyr BP mark do come with decreased reliability (Pettitt *et al.* 2003) and interpreting radiocarbon dates do come with considerations (Higham 2011).

When selecting suitable genes, Ho and Shapiro (2011) suggest using loci with high evolutionary rates and high informative content, either in the form of sequence length or variable regions. Currently, the Neanderthal sequences have low information content (Debruyne and Poinar 2011). However, improved sequencing technology continues to yield a vast amount of Neanderthal DNA data, including autosomal and mitochondrial (Table 6.1) and, with it, better quality and higher coverage. In addition, using multi-locus data increases the accuracy of obtaining demographic histories (Ho and Shapiro 2011).

Bayesian Considerations

While BEAST does estimate a genealogy, evolutionary model and demographic history, the output is dependent on the priors. The accuracy of the priors, therefore, becomes paramount. Figure 1 in Dalen *et al.* (2012, 1894) is the most recent phylogenetic tree estimated using BEAST (Drummond *et al.* 2012), using the mitochondrial control region and the HKY substitution model (Strimmer and von Haessler 2003). The phylogenetic results produced by Dalen *et al.* (2012) are supported by Fabre *et al.* (2009), where the Neanderthal population is divided into east and west sub-populations. However, Fabre *et al.* (2009) do specify a third southern Neanderthal sub-population. Nevertheless, this should dictate thorough sampling within a tree. In a previous study, Briggs *et al.* (2009) analysed five complete mitochondrial genomes under the Kimura-2 substitution model. Knowledge of the selected gene(s) becomes important as this directs the substitution (evolutionary) model and the mutation rate used as input. In this case, it is worth considering that natural selection may be acting on the mitochondrial genome and to different extents within the genome (Endicott *et al.* 2010) which can be accounted for (Soares *et al.* 2009). Additionally, focusing only on the mitochondrial genome will produce a demographic history reflecting only a quarter of the true Ne due to mode of inheritance. This further emphasises the importance of using multi-locus data. A revision of the human mutation rate has implications in the calibration of Neanderthal and modern human divergence, and consequently Neanderthal mutation rate estimates (Scally and Durbin 2012).

Finally, developments in software programmes can provide for the complexity within demographic models, which is highlighted by Alves *et al.* (2012), who argue against Neanderthal and modern human interbreeding by invoking alternative demographic scenarios to explain the results. BayeSSC incorporates a variety of demographic scenarios, and BEAST now includes different demographic models and multi-locus datasets (Drummond and Rambaut 2012). This ensures a thorough analytical platform to enable demographic reconstruction.

Animals as proxies

In this study, bison were used, due to the large quantity and quality of the data, to systematically identify the minimal requirements for genetic data to obtain a demographic model. The results highlighted specific factors that confound the data. In this respect, the bison dataset by proxy has proved invaluable in identifying key criteria important for the Neanderthal genetic data.

In this paper, it was suggested that demographic models could be compared between Neanderthals and hyaenas due to possible sympatry. But studies continue to reveal species specific responses. Thus, even with a demographic model for the Neanderthals, using animals as proxies does not seem possible. But it can provide a general comparison for the Neanderthal demographic model within the topic of carnivore extinctions. Nevertheless, the hyaena analyses here do support results obtained from the bison analyses – appropriate sampling. Therefore, using animals as proxies can be a valuable tool depending on the context as long as limitations are acknowledged.

Concluding Remarks

Currently, the Neanderthal genetic dataset lacks the quantity and quality to reconstruct a demographic model that can identify their extinction triggers. This study has used animal genetic data to identify what the Neanderthal dataset requires in terms of quality and quantity, sampling, and factors affecting demographic model retrieval. Using animals as proxies remains problematic, but it may be possible to utilise them in a wider context instead. The results here have highlighted three key considerations that are required of the Neanderthal genetic data for demographic reconstruction – archaeological, sufficient sampling, and Bayesian – thereby achieving the stated goal. Despite the limitations of the Neanderthal dataset, continued development in sequencing technology and analytical methods allows for improved genetic datasets and more accurate analyses providing a framework for demographic reconstruction allowing questions on Neanderthal extinction to be answered.

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7. Le Cuzoul De Gramat (Lot, France): A key sequence for the early Holocene in southwest France

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Abstract

Explored for the first time by Lacam between 1920–1930, the Cuzoul de Gramat is one of the most famous French Mesolithic sites. Since 2005, a series of new excavations have been undertaken. The aim of this paper is to propose an assessment of our recent work, which outlines previous data and confirms the significant residual archaeological potential of the site, which is about to quickly become an important regional sequence for the first half of the Holocene.

Introduction

The Causses of Haut-Quercy, located between the Pyrenean and the Massif Central mountain ranges, offer one of the most important concentrations of Mesolithic sites known within southern France (Valdeyron *et al*. 2009). Among those sites, Cuzoul de Gramat, explored for the first time in the 1920s and 1930s by Lacam, is particularly famous (Lacam *et al*. 1944). The site is located in the centre of the karstic plateau of Gramat (Causse de Gramat) in the northern part of the Lot region (Figure 7.1). This low altitude Causse (average 300 m above sea level) displays a remarkable number of dolinas, swallow holes, and subterranean rivers.

This system of valleys, plateaus, and slopes offers a variety of habitats in the present day with abundant animal, mineral, and vegetal resources. This seems to have been the case at least since Mesolithic times, with red deer, boar, and roe deer being the most hunted animals at a regional scale during this period (Valdeyron *et al*. 2011). In terms of mineral resources, flint is locally abundant and generally of very good quality. It is found in secondary or tertiary formations in primary deposits or in the alluvial deposits of the rivers Dordogne, Lot, and Célé. The raw material analysis indicates that the occupants of Cuzoul obviously took advantage of these local resources (at distances less than 20 km) (Constans 2013).

The regional vegetation history can be reconstructed today thanks to recent charcoal data from five prehistoric sites located on the Causse de Gramat, including the first charcoal samples collected in secure stratigraphic contexts from Cuzoul (levels in place dated by radiocarbon; see below). These indicate three major phases of landscape evolution (Henry *et al*. 2013). While the late Glacial is marked by the early decline of softwoods (mainly juniper and scots pine) and their almost complete disappearance, the early Holocene sees the development of oak and its associated taxa in a highly contrasted landscape. Hence, the vegetation surrounding the Mesolithic sites of the Causse de Gramat is already characterised by the absolute dominance of a variety of broad-leaved trees and shrubs. During the early and middle phases of the Mesolithic, deciduous oak woodlands develop progressively, at the cost of shrubby clearances and fruticeae of Rosaceae prunoideae and maloideae. The late Mesolithic seems to be marked by an increase in humidity and the installation of more mature formations in the form of oak woodlands with a higher biodiversity. However, the improvement of the climatic conditions during the course of the Atlantic period did not lead to a significant increase of Mediterranean taxa, as can be observed nowadays on the Causse. The vegetation seems to remain strictly supra-Mediterranean at least until the Bronze Age (*ibid*.).

The aim of carrying out new excavations is not only to validate, but also to complete the observations made by our predecessors. Since archaeological knowledge has increased and a whole number of analytical tools and methods have been developed over the last decades, we hope to acquire in the following years an interdisciplinary vision of the nature and function of the successive occupations of Cuzoul de Gramat. In this paper, we will discuss both the old excavations, as well as present the first results from recent fieldwork.

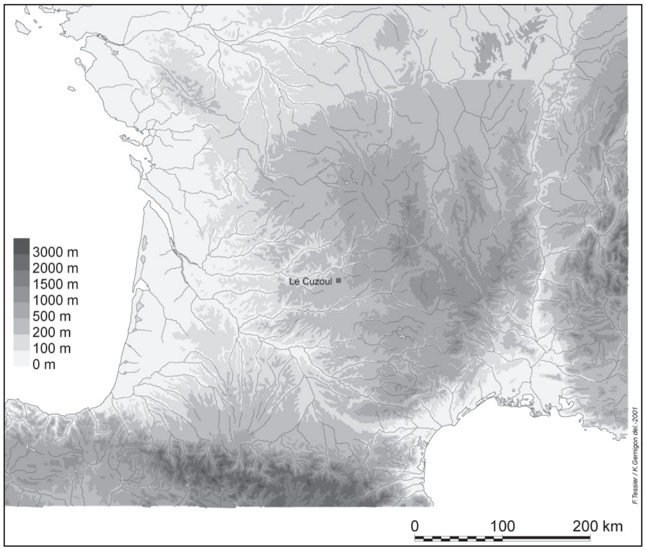

Figure 7.1. Geographic location of the site of Le Cuzoul de Gramat (drawing by N. Valdeyron, map from F. Tessier and K. Gernigon).

Presentation of the site and history of the archaeological investigations

The site is located at the bottom of a large dolina, one of the 'cloups' that are so typical of the landscapes of Quercy. However, this configuration is quite rare, since the size of the dolina easily exceeds what prevails in other neighbouring sites, such as Escabasses, or even Roucadour. The flat bottom of this oval-shaped depression stretching towards the north-northwest is more than 200 m long and 100 m wide. These unusual dimensions give the site an almost monumental appearance. The feeling of confinement, so common in these depressions, which are often surrounded by trees, is entirely absent here. This impression, in addition to the effect induced by the dolina's considerable size, is also due to the relatively shallow slope of its sides, which are only rarely vertical and are often in the form of small terraces. These structures testify to the former agricultural function of this vast natural humidity reservoir, which now is only used for sheep and cattle, but which was formerly utilised for cereal cultivation.

The site itself, formed by the cavity and the surrounding area, opens in a bank of Jurassic limestone, forming a rocky escarpment up to 10 metres high and facing east (Figure 7.2). On both sides of the entrance to the cavity, the limestone stretches for several tens of meters, forming a continuous line of shelters of varying depth (Figure 7.3). A wall forms a raised passage (2 to 3 metres wide depending on location) between the limestone wall and the bottom of the dolina, bounding

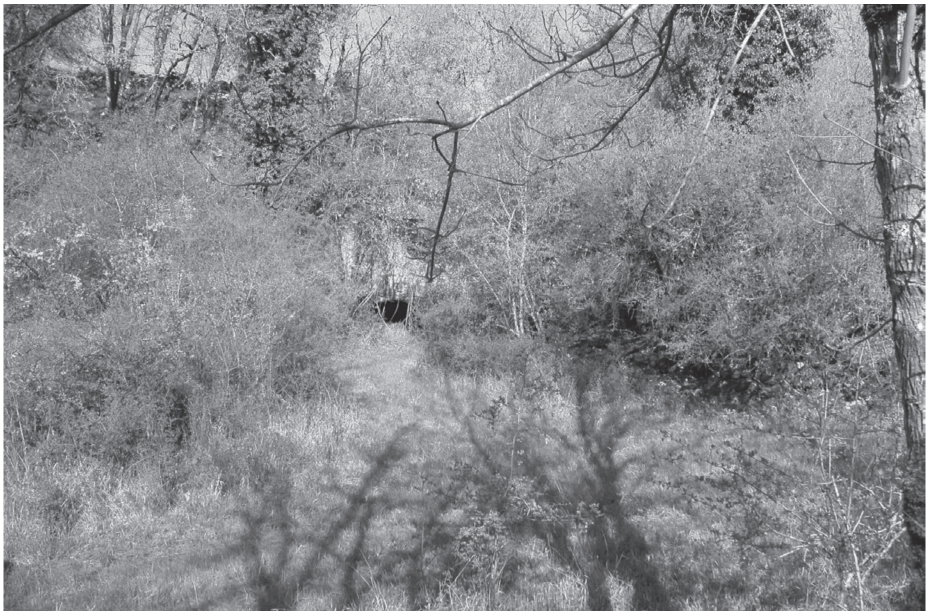

Figure 7.2. View of the entrance of the cave from the bottom side of the dolina (photo by N. Valdeyron).

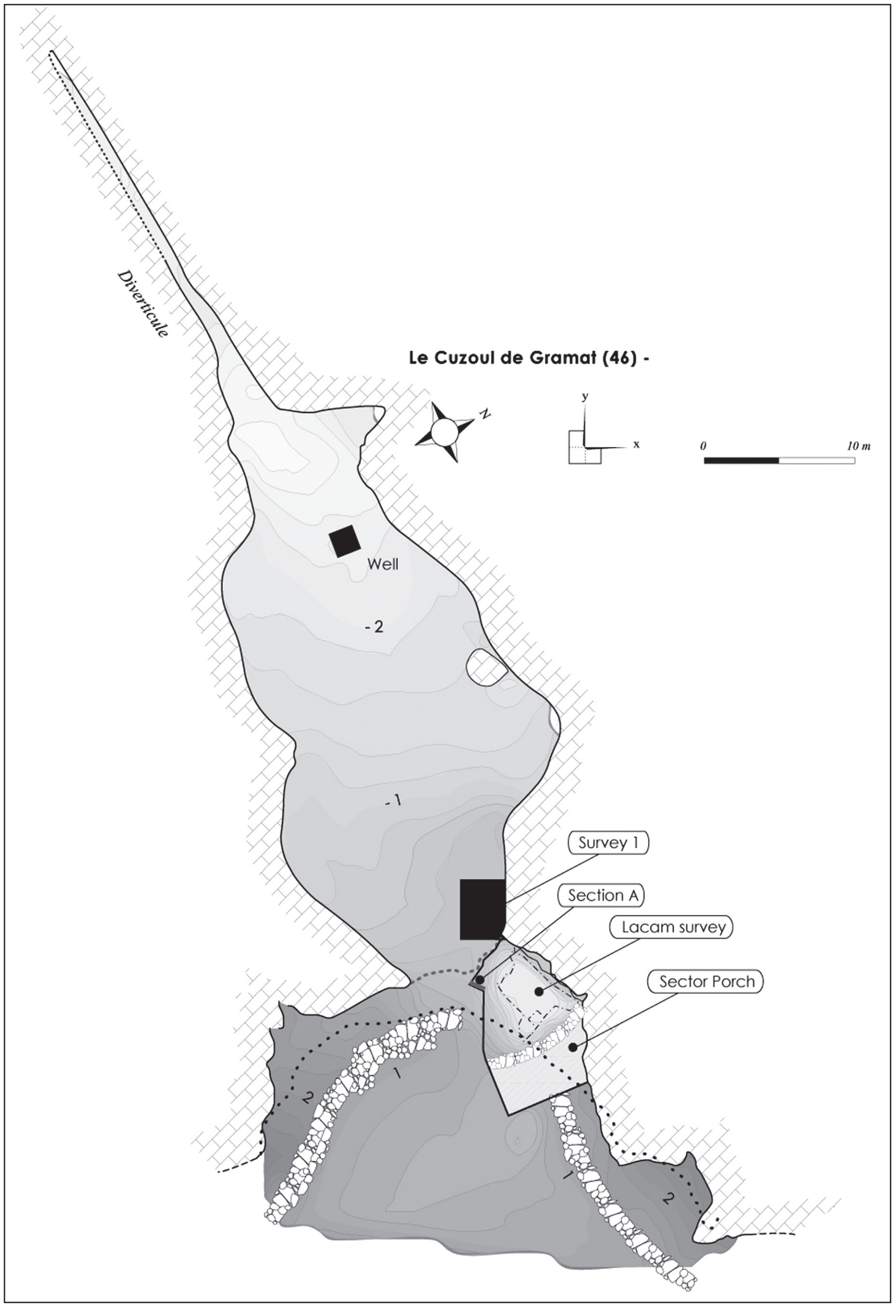

Figure 7.3. Map of the deposit with various sectors explored (drawing by N. Valdeyron).

its western side. This corridor, which extends beyond the rock fall, is an old access road from the top of the plateau. The north side contains a similar feature; however, once past the area of the porch itself, the rapid reduction of the height of the wall quickly limits the protective nature of the rock fall.

Currently, the entrance to the cave, which is almost 6 meters wide and relatively low (2 metres in height up to the level of the spire), leads directly to a first relatively large chamber (40 × 15 × 3 m), at the bottom of which a man-made well protects a perennial captive sheet. Beyond the well begins a narrow, but passable corridor leading, after a few hundred feet, to a second, significantly smaller chamber (8 × 3 × 2 m). Only the first chamber, two thirds of which is regularly flooded in winter by the rise of the water level, has yielded evidence for prehistoric occupation.

If we refer to the official version (Lacam *et al*. 1944), the only work on the site was performed by Lacam and Niederlender, who operated continuously from 1923 to 1933. First, three trenches were dug inside the cave. Their exact location is unknown, but they were probably located deep inside the first chamber, as comments by Lacam suggest that the stratigraphic levels found were heavily disrupted by the presence of the water table. This fact led the excavators to start working outside the cave, in the North shelter, from 1927 onwards. Here, a stratigraphic sequence of more than four meters was uncovered, which revealed, in particular, several Mesolithic levels. These levels, containing trapezes, were attributed to the 'Tardenoisian'.

At the base of these 'Tardenoisian' levels, the discovery of the burial of a young adult ensured the celebrity of the site; the official excavation was extended until 1933, when the cutting under the porch was closed and back-filled. Lacam's excavation logbooks tell us that he actually returned to the site long after its closure. For example, in 1947 he opened a cutting of a few square metres, located about ten metres in front of the rock-shelter. This allowed him to locate the stratigraphic sequence he had already observed under the porch. This information is important, because it suggests that the site extends into the dolina – and is well preserved – beyond the area of the rock-shelter, which could indicate the presence of open-air occupation at the site.

New works: evaluating previous findings, obtaining new data

As a first step and in keeping with what was originally asked of us, our excavations were restricted to the porch where Lacam's excavation had taken place. The back-fill from Lacam's trench was re-excavated and fully sieved. This titanic operation involved the processing of almost 70 m^3 of sediment and occupied us for the first three excavation seasons.

After this, one of the edges of Lacam's trench was selected to act as a reference section (called 'Section A'), which to date has attained the upper Sauveterrian levels. Inside the cavity, in the continuity of Lacam's survey, a sondage (referred to as 'Survey 1'), small at first and progressively enlarged, was opened during the second campaign in order to access in situ levels as quickly as possible. In 2008, the excavation reached the top of the Mesolithic sequence. Finally, a fourth excavation area (called 'Sector Porch') was opened. This corresponds to the control area, unexcavated by Lacam, and separated from his trench by a stone wall built at the time of the site's closure (Figure 7.3). We present below the preliminary results obtained so far for the first three excavation zones, since in situ levels have not yet been recovered from the Sector Porch.

The 'Survey Lacam'

In this area, there was no new excavation since only the sediment of the former excavation was removed and sieved, *i.e.* an infilling resulting from the mixing of all levels excavated by Lacam, from the Epipalaeoltihic to the Neolithic. Consequently, neither stratigraphic nor specific data relating to the sedimentary context have been obtained. However, the residual information yielded by this survey is important and confirms, and sometimes even adds, to what we already knew. Several thousand additional artefacts, mainly lithic, have been recovered. Among these are hundreds of stone and abundant animal bone tools, many faunal remains, as well as Neolithic or more recent pottery fragments, the latter being less well represented. An obvious but important point to make here is how the lack of sieving in the earlier excavations greatly limited the representativeness of Lacam's collection. This is true regardless of the quality of Lacam's work, which should also be recognised. Luckily, the abundant material that was collected helped to clarify the different occupation phases of the site, either by providing more precise cultural data or by substantially completing the general picture suggested by Lacam.

The earliest occupation reaches back to the Azilian period, perhaps to a classic phase of this culture, even though its chronology is still poorly understood in the Quercy region (Valdeyron & Detrain 2009). Probably on the basis of the observation of mixed assemblages, Lacam identified what he called an Azilo-Sauveterrian layer I (titles have varied, since the terms 'Sauveterrian' and 'evolved Post-Azilian' were also used, but the corresponding assemblages were clearly mixed). Material collected in the backfill from Lacam's excavations clearly calls for the attribution of this first occupational phase to the Azilian only (Figure 7.4), *e.g.* a series of curved backed points (No. 1–10), no true Malaurie points, and a few tools made on blades, including one truncated blade with bilateral retouch (No. 11). These finds are representative of the local Azilian tradition as it is found, for example, in the layers of Murat shelter, or in Level 4 of Pégourié (*ibid.*). The distal part of a unilateral antler harpoon (No. 17) completes this assemblage. Three drilled deer canines may be connected to this assemblage, though they could also be more recent (No. 12–14). Two bone fragments carry fine engravings, organized in parallel lines on one (No. 15), while the other exhibits a more complex organisation (No. 16). These decorations appear to be non-figurative.

In the vision of the site developed by Lacam, the Azilian pieces appear mixed with industries that can today be attributed to an early or middle Mesolithic phase. These industries are largely underrepresented

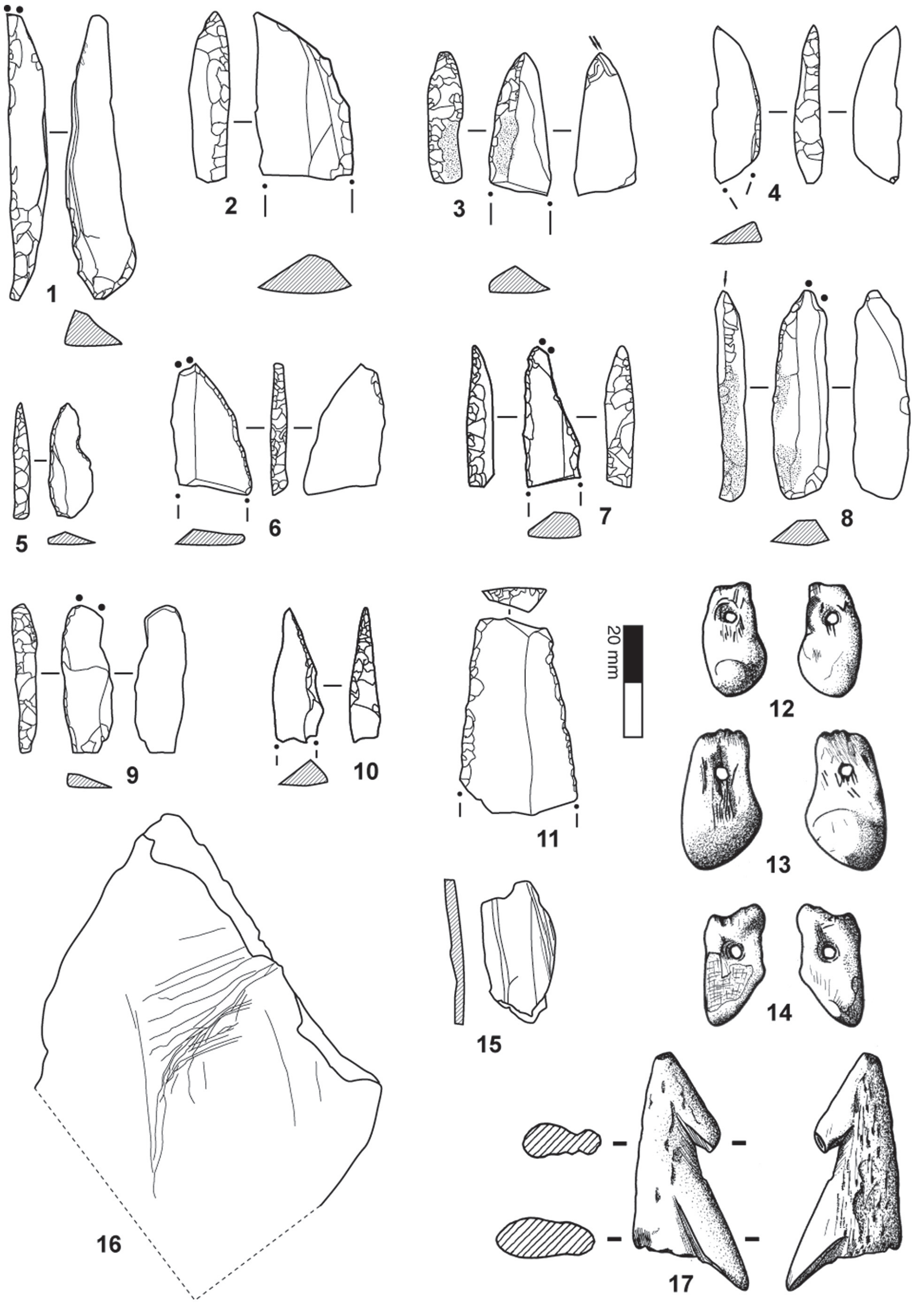

Figure 7.4. Survey Lacam: lithic and bone material assigned to the Azilian (drawings by N. Valdeyron and B. Marquebielle).

in the earlier work because of the absence of sieving. Even though the interpretation resulting from the examination of the material collected from the backfill of Lacam's trench and found while restoring 'Section A' (see below) must remain cautious, it seems clear that a Sauveterrian occupation succeeded the initial Azilian occupation. This interpretation is based on the characteristic nature of some microlithic armatures, particularly geometric triangles. Even though isosceles forms are rare, a relatively important amount of Montclus triangles, or other pieces related to this type, have been identified, which clearly indicate the occupation of the site at the end of the Early and/or during the Middle Sauveterrian.

The majority of the typical material, *i.e.* the artefacts likely to provide a chrono-cultural diagnosis, alludes

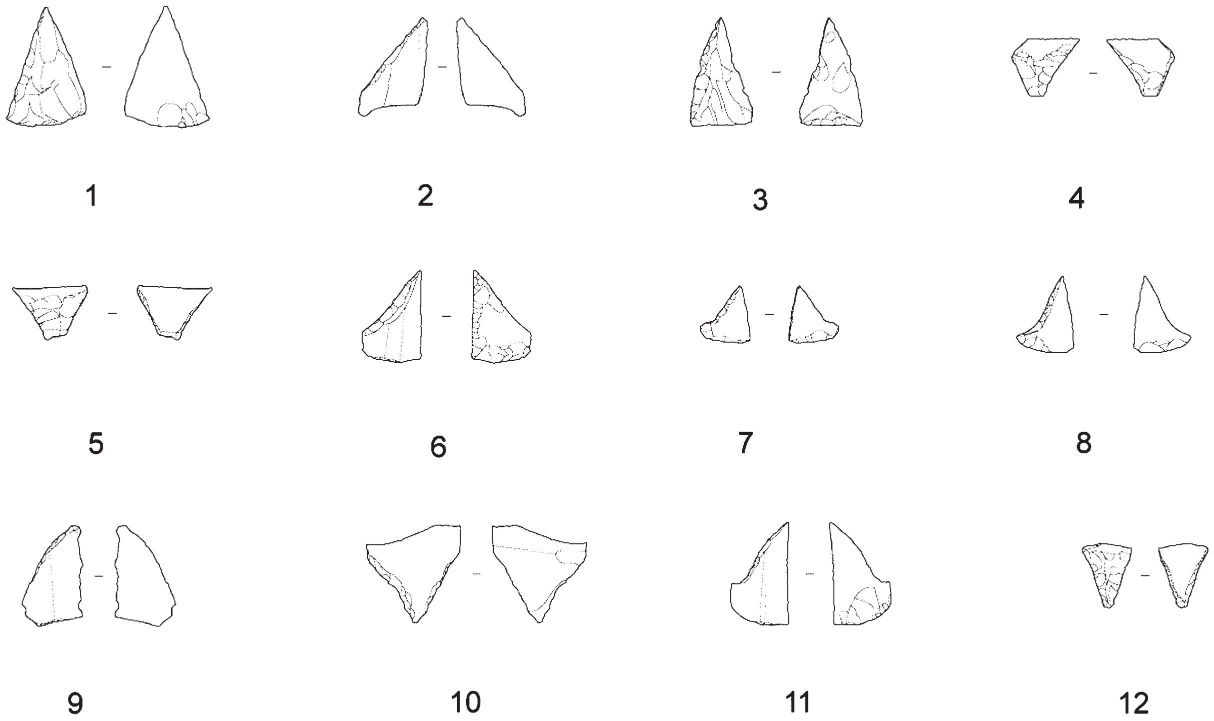

Figure 7.5. Survey Lacam: lithic material assigned to the recent/final Mesolithic (drawing by N. Valdeyron).

to occupation at the end of the Mesolithic period. This is true of the raw products obtained by indirect percussion, for notched or denticulate blades (Montbani type), many large armatures represented by a wide variety of trapezes (Figure 7.5, No. 2, 6, 7, 8, 9 and 11), triangular points (Figure 7.5, No. 1 and 3) or Montclus arrow type armatures (Figure 7.5, No. 4, 5, and 12). A preliminary use wear analysis of about a hundred notched blades showed a good state of preservation and demonstrated that they were voluntary tools used to scrape narrow pieces of wood, bone, or plant. Numerous bone and antler artefacts were also found in this context. Their cultural attribution is difficult, firstly because they mainly represent the waste of débitage items and secondly, because the exploitation of osseous materials during the Mesolithic is not yet well understood. Nevertheless, numerous objects fit into the technical transformation scheme of the recent/final Mesolithic, known from the study of Lacam's collection (Marquebielle 2007), which showed that antler exploitation was organised following a débitage by sectioning.

The following occupation phase had previously gone completely unnoticed. It must be said that it is attested to only by a small number of objects, which were not known to be diagnostic or specific to the early Neolithic at the time of Lacam's study. Surprisingly, but very positively, it seems several elements can be attributed to this period. These include a Betey segment, with its characteristic bow in double-bevel (Figure 7.6, No. 2). There is also a Châtelet arrow type (Figure 7.6, No. 1), with a typical isosceles triangle form and semi-abrupt bifacial retouch formed from two truncations (on this piece, only one of two truncations meets this definition). The length of the cutting edge, close to 15 mm, remains within the limits of the type. These two objects are certainly the most significant. Without great conviction however, another sharp armature could also be added to this small assemblage (Figure 7.6, No. 3). Finally, a pottery fragment, representing a decorated lip, could also support an attribution to the early Neolithic (Figure 7.6, No. 4).

No presence on the site during the Middle or the Late Neolithic can be detected in the material from Lacam's excavations, nor on the basis of his 1944 publication, or the Museum collections. However, an intense occupation during the Chalcolithic/Bronze Age, having already been indicated by a date obtained from a pit discovered in 2005 inside the trench opened in the dolina (Ly 1237, 3510 ± 70 BP, *c.* 2026 to 1643 cal. BC), is clearly present. It is represented by a beautiful series of tanged arrowheads covered with bifacial retouch, associated with other types of armatures with the same type of retouch (Figure 7.6, No. 5, 6, 7, 8 and 10). An equally beautiful pottery shard belongs to the same chronological window, *i.e.* typical of the middle

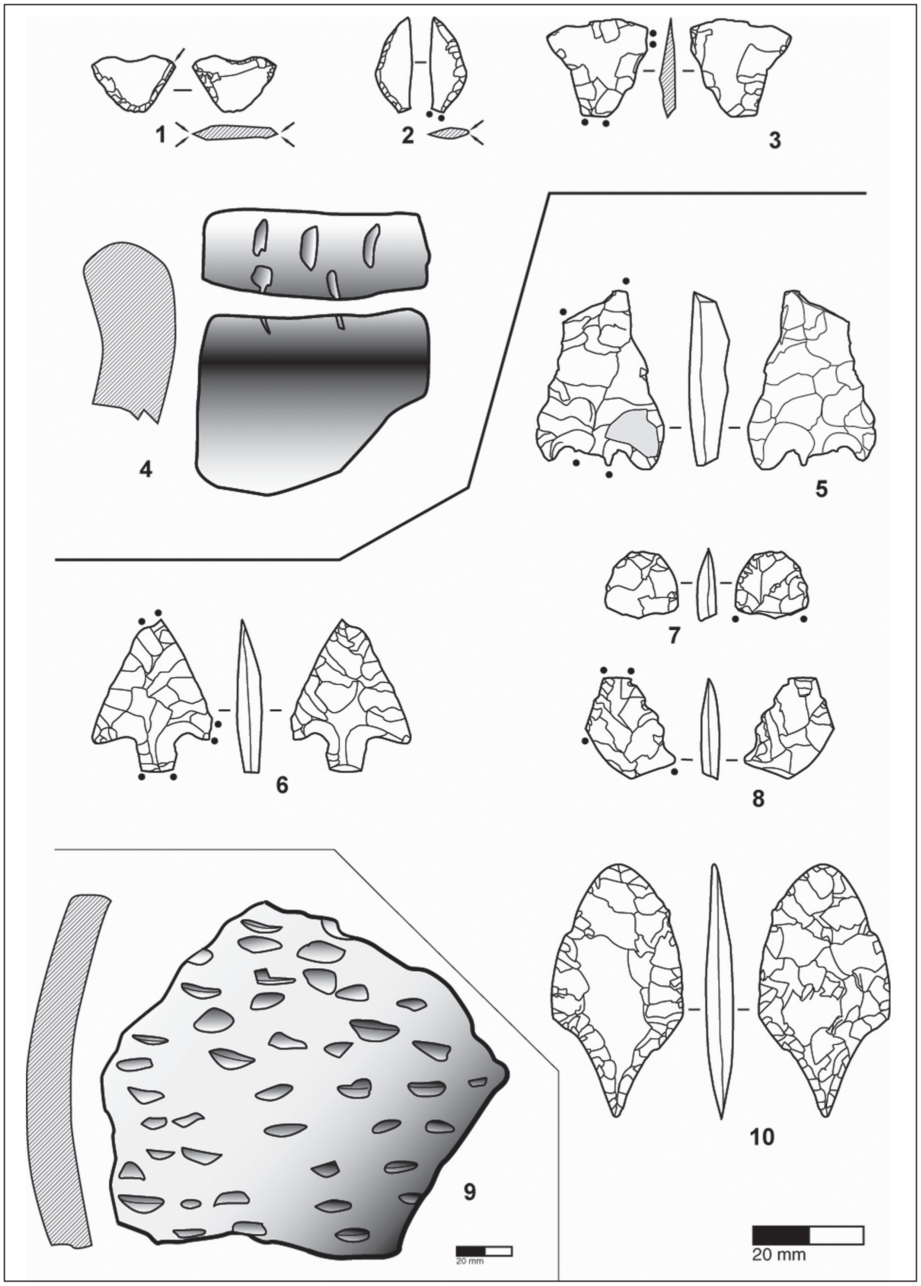

Figure 7.6. Survey Lacam: lithic and ceramic material assigned to the Early Neolithic and to the Bronze Age (drawing by N. Valdeyron).

Bronze Age as it appears, for example, in level A1 of Roucadour (Nierderlender *et al*. 1966), or in a more reliable context from the same site, in level C1 of a recent excavation (Gasco 2000, 2004). The pinched, flat buttons decoration on this body fragment is indeed quite comparable to that described for Roucadour (Figure 7.6, No. 9). A fragment of cordon decorated with finger top impressions may also relate to the same horizon.

The subsequent occupation phase is suggested by a small assemblage (barely seven pieces) of pottery fragments that had gone unnoticed. These bear no typical decor or shape. The major discriminant element is the paste, which is grey to black and fine, with an extraordinarily fine temper containing mica inclusions, typical of the extreme end of the Quercy Bronze productions (Gernigon *et al*. 2000).

After the end of the Bronze Age, the site was clearly occupied on several occasions. Again, the chrono-cultural diagnosis has been established on the basis of

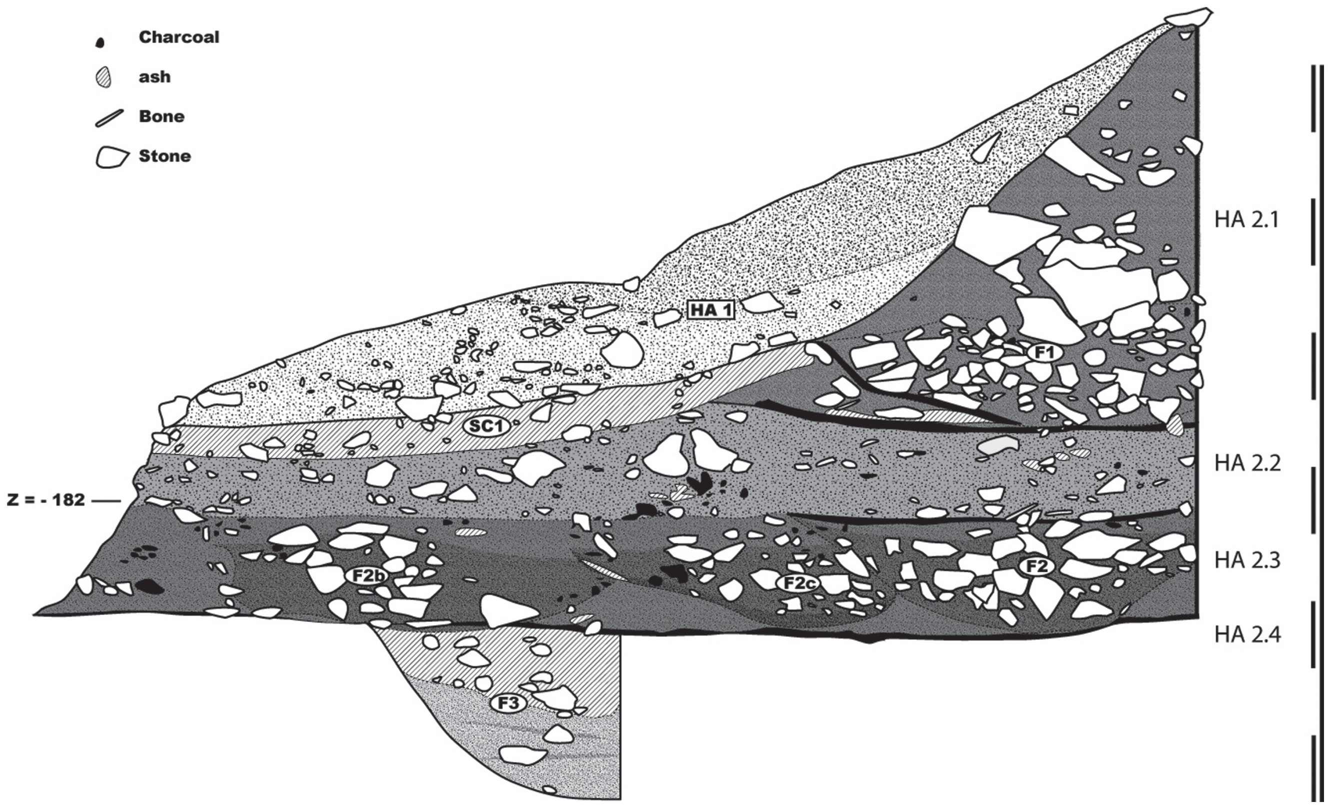

Figure 7.7. Survey Lacam: stratigraphic profile 'Section A' (drawing by N. Valdeyron)

the ceramics. Some pieces evoke the Iron Age I. The antiquity is also represented by amphora fragments and common ceramics. There is also possibly material from the early Middle Ages and, more assuredly, the modern era.

'Section A'

Located on one of the sides of Lacam's excavation trench, this reference section is still being worked on. Therefore, the data presented below are limited to its upper part. This careful excavation corresponded at first to a very limited excavation area (15 × 70 cm at the top), which now exceeds 1.5 m^2 at the deepest levels. This has allowed us to gain an insight into the sedimentary dynamics in this area (Figure 7.7). They are marked for the most part by anthropogenic inputs (in the form of ash, charcoal, chips of snail shells, limestone rocks *etc.*). These are complemented in variable proportion (according to the levels), by more or less coarse natural inputs from the shelter's wall, which may have fallen from the cliff, or have arrived in the shelter via the two lateral screes, which converge towards the cavity's entrance.

Without going into a detailed characterisation of the sedimentary processes, the following elements can be noted:

1) The whole sequence (just over 1 m deep), is characterised by a very large amount of combustion features, showing a strong morphological and structural variability.
2) The sediment, poor in clay, is heavily loaded with ash and charcoal.
3) There are no sterile levels between the various archaeological deposits: whitish layers, identified by Lacam as 'sterile', are actually thick ash beds.

Three successive archaeological horizons have been identified in this area (from top to bottom). HA 1 is a pocket of disturbed sediment fallen (or voluntarily collapsed?) into the survey, likely at the time of its seal by Lacam. HA 2 is about 90 cm thick in the area where it is best preserved. This level seems to include mostly occupations belonging to the second Mesolithic (more recent assemblages may also be present). Barely started in 2008, HA 3 is also several tens of centimetres thick. It has delivered material relating to the Early and/or Middle Mesolithic (Figure 7.8, No. 31–38).

Several radiocarbon dates have been obtained for HA 2, giving the first series of indications as to the chronology of the site's occupation during the second

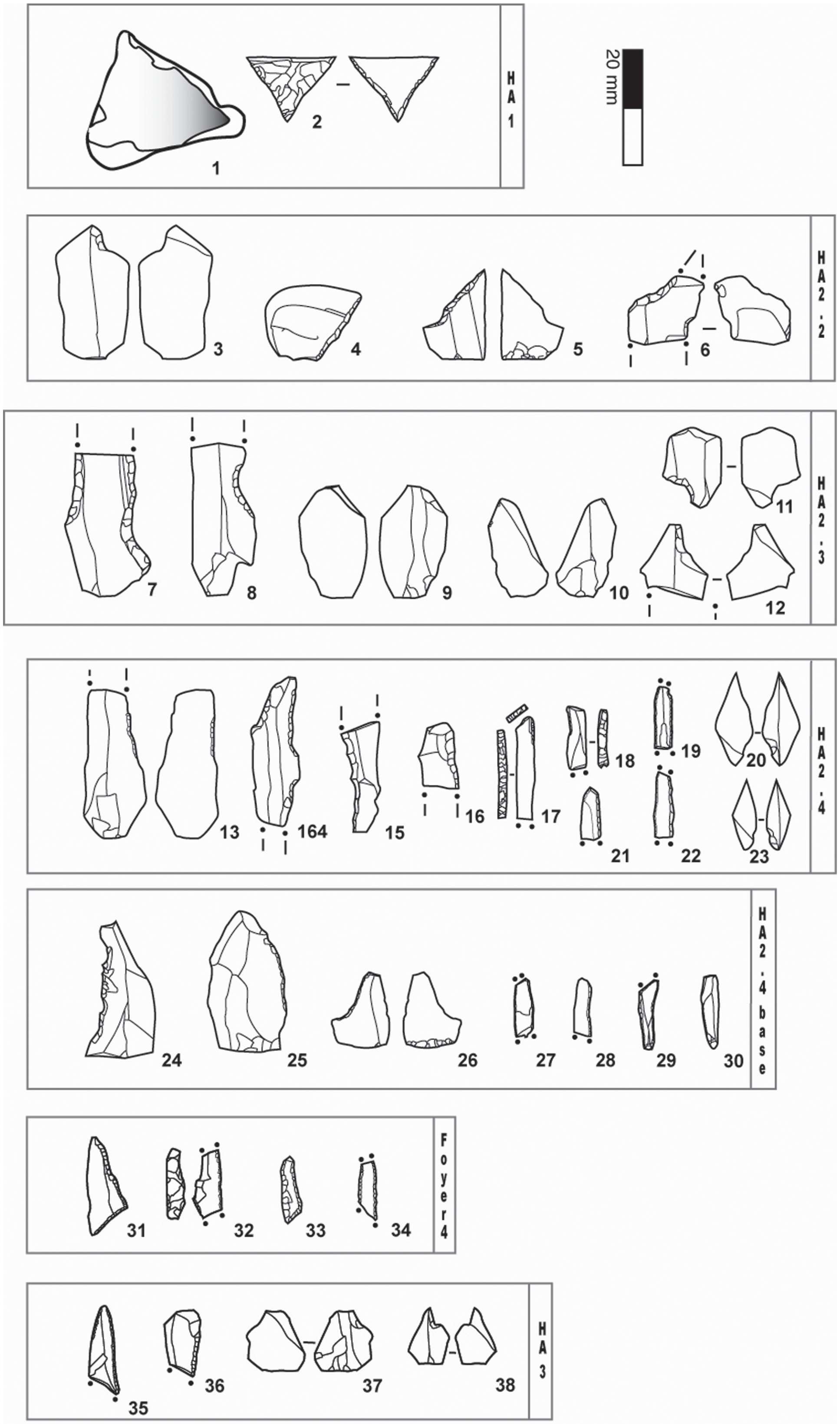

Figure 7.8. Survey Lacam: lithic material, classified by stratigraphic unit, from 'Section A' (drawing by N. Valdeyron).

Mesolithic (see Table 7.1). The lithic assemblages associated with these dates consist, for the most part, of diagnostic elements, such as broad armatures (trapezes of the 'Martinet' type and 'bastard' points), deep-notched blades and bladelets, as well as microburins, all made on regular and quite broad elongated supports (Figure 7.8, No. 3–12). These associated artefacts characterise the upper part of the horizon (Ly-14204). In the lower part (Ly 14205 and 14459), the same types of artefacts are present (Figure 7.8, No. 13–16 and 24–26), but here they are associated with back edged pieces, made on narrower blades (Figure 7.8, No. 17–22, and 27–30), belonging to the Sauveterrian tradition.

Of course, the coherency of these lithic assemblages has to be tested, since the conditions of their recovery do not allow them to be categorical for the moment. Our excavation area is still too small and located in a zone where several combustion pits may have disrupted the local stratigraphy. In any case, the data collected inside the cavity (see below) may be discordant, which also calls for caution.

'Survey 1'

Opened in 2006, Survey 1 has been set up in the entrance area of the cavity, against the North wall, just a few metres from the limits of Lacam's survey excavation. Initially of limited size (2 m^2), it has gradually been expanded and now occupies an area slightly larger than 10 m^2.

The upper part of the fill (US SG3100, 3200 and 4300) reflects the cave's pastoral function during the modern era: the clay rich sediment results essentially from the taphonomic evolution of the excrements contained in the litter. Several features from this period (including the construction of a path and a pit-silo) disrupted the strata, destroying the first Mesolithic levels in places, and resulting in the prehistoric material being mixed with shards of glazed ceramic.

Below the levels attributed to modern times, a thin level limited to a few square metres delivered an archaeological soil (US SG 4550 and 4560) dating to the late Bronze age as indicated by the ceramic artefacts. A few typical potsherds are associated with coarser ceramic (such as the remains of a flat bottomed container), all arranged around a plain (SG 4200) structure marked by a thick base of rubefied clay.

Immediately below the Protohistoric (and also over dug in places by the base of the hearth) appears the first Mesolithic level (SG 5100). This consists of fine alternations of grey-brown sediment and ashes, and regular stratigraphic controls allowed for a very reliable planimetric exploration. This stratigraphic unit, which is a dozen centimetres thick, lies over a (perhaps) more compact grey, ashy level (SG 5200), which has been explored over a small area. Both have delivered relatively abundant archaeological material, consisting mostly of lithic pieces, bone remains, and whole or broken shells of the grove snail (Cepaea Nemoralis). Some osseous material was also discovered in these levels. In particular, a basal part of a red deer antler (US 5200) was exploited following the same débitage by sectioning method known from the study of Lacam's collection. The chronological framework of bone and antler exploitation on the site can thus be clarified a little.

Hearth No.	Radiocarbon (and calibrated) date
Hearth F1	Ly 14204: 6200 ± 45 BP (5297 to 5038 cal. BC)
Hearth F3	Ly 14205: 6490 ± 40 BP (5525 to 5368 cal. BC)
Hearth F2b	Ly 14459: 6760 ± 60 BP (5749 to 5558 cal. BC)

Table 7.1. Radiocarbon dates that have been obtained for HA2.

At first sight, at least, the lithic material collected in these first two Mesolithic levels appears quite homogeneous and can, therefore, be attributed to the same occupation phase (Figure 7.9, No. 10–30). The common tools consist of notched blades and bladelets. The armatures are represented by asymmetrical trapezes (essentially of the Martinet type) and by long and, more rarely, short triangular points, among which are several so-called 'bastard' points. There are no narrow back edged pieces in this assemblage. Microburins made on large and broad supports are abundant. The date obtained for SG 5220 (Ly 14458: 6815 ± 40 BP, c. 5743–5638 cal. BC) places this set in a chronological position comparable to that of the hearths F3 and F2b from 'Section A', in which, as we mentioned before, broad armatures were associated with narrow back edged pieces. One of the hypotheses that can be proposed to explain this discrepancy in the range of armatures is that it is the result of taphonomic processes. Indeed, they seem to have been of consequence in relation to 'Section A', where the pits resulting from the construction and the use of the combustion features may have contributed to mixing the sediments and their associated (in this case, Sauveterrian) material. On the contrary, 'Survey 1' is clearly located in an area that has not been subjected to these types of post-depositional processes and the material can be considered as genuinely homogeneous.

Conclusions and perspectives

This brief presentation of the history of archaeological work on the site shows that the residual documentary potential of Cuzoul de Gramat, particularly given

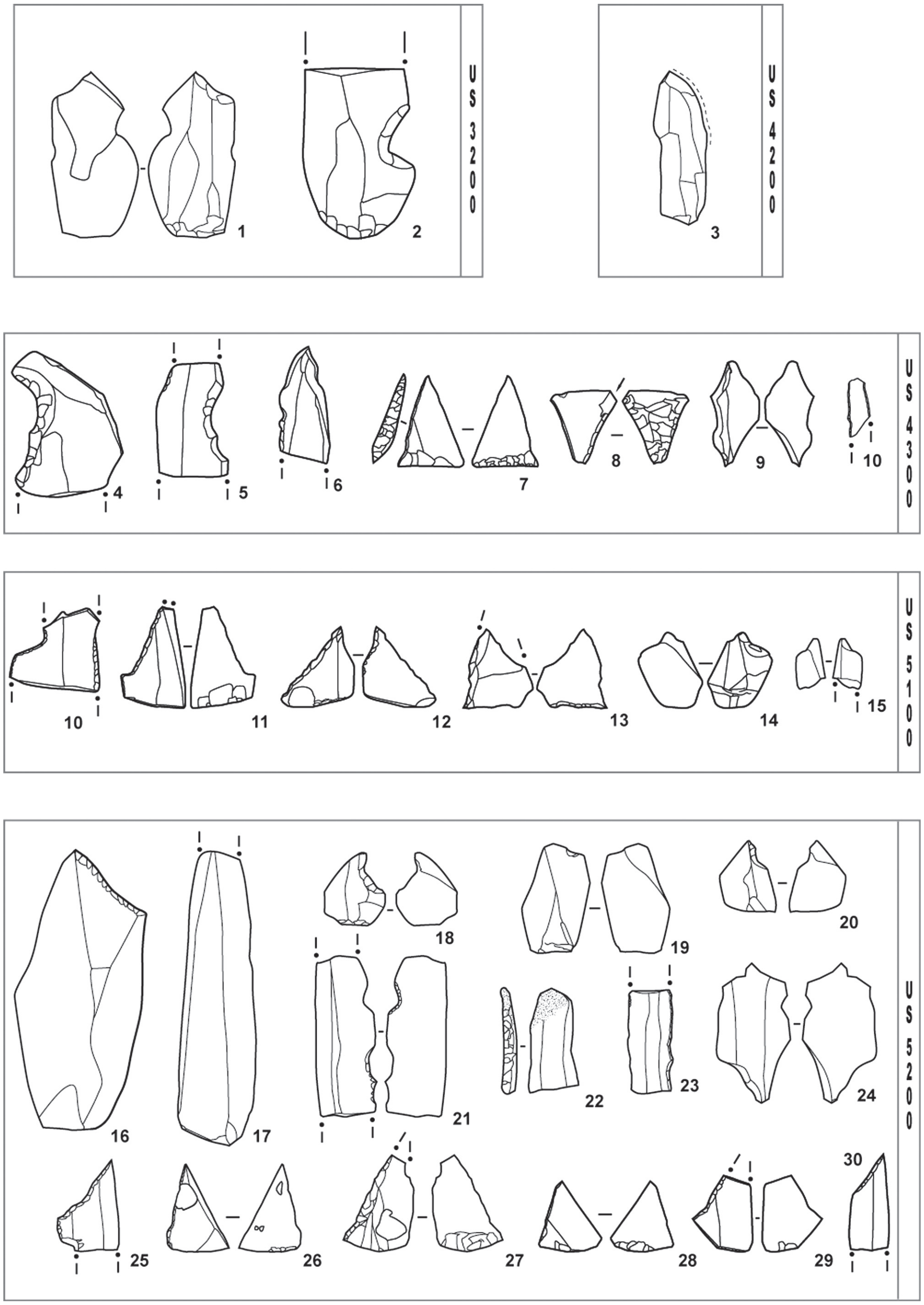

Figure 7.9. Recent/final Mesolithic lithic material, classified by stratigraphic unit, from 'Survey 1' (drawing by N. Valdeyron).

the extent of the old excavations, can be described as very important. The long sequence of Cuzoul, in the beautiful publication of 1944 by Lacam *et al*. (1944), has been confirmed and even added to by our preliminary results. Indeed, when the site was specifically targeted for studying the end of the Mesolithic, other periods that were not expected (*e.g.* the Early Neolithic or the Bronze age) could also be identified. Therefore, Cuzoul could become a reference site not only for the end of the Mesolithic period, but also for a number of other chronological phases hardly better documented on a local, regional, or sometimes even extra-regional scale. Without of course neglecting the interests of the Historic and Protohistoric occupations, since the corresponding levels have been explored with the same attention and the recovered vestiges have been entrusted to recognized specialists, it is now the Mesolithic sequence and the two periods surrounding it (*i.e.* the Azilian and the early Neolithic) which will hold our attention in the coming years.

Beyond the characterisation of the material productions, for which a defined number of studies are already available, such as that of the Lacam collection by Marquebielle (2007), our ambition is to provide an integrated approach to the site, representing the interdisciplinary nature of the researchers involved in this project. Even though the palynological testing inside the outer trench was inconclusive, charcoal and seed analyses have already begun and indicate the site's potential for documenting palaeoenvironmental, as well as palaeoethnobotanical issues (Henry *et al*. 2011, 2013).

We hope to be able to present the first results of other approaches soon, such as raw material procurement, use-wear and zooarchaeological analyses, which will contribute to developing a wider reflection on the functional status of the occupations and the area that the site and its territory occupied in the Mesolithic landscape.

Acknowledgements

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8. Human Craniometric Variation Supports Discontinuity at the Late Glacial Maximum in Europe

Ciarán Brewster, Ron Pinhasi and Christopher Meiklejohn

Abstract

Skeletal differences between early Upper Palaeolithic and later modern human groups have often been interpreted as evidence of substantial gene flow between the former group and Neanderthals. However, this pattern may also arise if there was a high degree of selection and/or lack of genetic continuity between early Upper Palaeolithic populations and those which followed. The impact of the Last Glacial Maximum (LGM) on Upper Palaeolithic humans is critical to such an interpretation. We use a subsample (n=76) from a larger, well-dated craniometric dataset to explore both temporal and geographic variation in Upper Palaeolithic and Mesolithic populations. In all analyses, the early Upper Palaeolithic consistently showed the greatest divergence, suggesting the LGM as a disruptive event in the genetic composition of Europe. No clear divisions were detected between the late Upper Palaeolithic, early Mesolithic and late Mesolithic. Based on the results presented here we caution against interpreting differences between Upper Palaeolithic populations and recent human populations in Europe as evidence for substantial gene flow between modern and archaic humans in the late Middle Palaeolithic and early Upper Palaeolithic.

Introduction

Two main theories have dominated the study of human origins for almost a century. First, the 'multiregional continuity' theory hypothesises that anatomically modern humans (AMH) evolved in parallel from archaic forms in various Old World regions (for example Brace 1964; Frayer *et al*. 1993; Hawks *et al*. 2000; Wolpoff 1989; Wolpoff *et al*. 1984, 2000, 2001). The second theory, known as the 'Out of Africa' model, proposes that all modern humans have an AMH ancestor from Africa around 160,000 years ago (Cann *et al*. 1987; Forster 2004; McDougall *et al*. 2005; Ramachandran 2005), which dispersed into Eurasia after 100,000, replacing all 'archaic' hominins without substantial admixture (Bar-Yosef 2002). Over the last three decades, the recent African origin model has gained increasing support from population genetics (DeGiorgio *et al*. 2009; Hellenthal *et al*. 2008; Jobling *et al*. 2004; Nei 1995), craniometric studies on modern populations (Manica *et al*. 2007; von Cramon-Taubadel and Lycett 2008), and evidence from the fossil record (Stringer and Andrews 1988). However, recent genomic data from archaic hominins has added complexity (Green *et al*. 2010; Reich *et al*. 2010), and some have suggested intermediate theories that allow limited admixture between incoming AMH and resident 'archaic' groups (*e.g.* Bräuer 1984; Bräuer and Rimback 1990).

Against this backdrop, the study of Upper Palaeolithic and Mesolithic humans took a backseat (Frayer 1984; Meiklejohn 1974). Some researchers who favoured a replacement model argued that modern European cranial characteristics were already established by the early Upper Palaeolithic (Campbell, 1992; Howell 1984; Klein 1989; Stringer 1974). In some cases the underlying assumption was that human evolution had come to a standstill with the appearance of 'Cro-Magnon' (Klein 1992, 1995) and that studying morphometric variation among Upper Palaeolithic humans would, therefore, not contribute to major questions in human evolution. Such a view derived validation from the work of Morant

(1930; see also von Bonin 1935), who concluded that Upper Palaeolithic skulls were strikingly homogeneous in space and time and "modern in almost all respects". Within this context it was accepted that changes were cultural rather than biological.

While some researchers (for example Henke 1989) found the people of the Upper Palaeolithic to be relatively homogeneous in cranial traits, others (*e.g.* Frayer *et al*. 2006; Rougier *et al*. 2007; Soficaru *et al*. 2006; Trinkaus 2007; Wolpoff *et al*. 2006) pointed to what they saw as clear cranial differences between early Upper Palaeolithic and later humans – features such as the variable expression of external occipital protuberances, pronounced brow ridges and broader faces. Others pointed to differences between Upper Palaeolithic populations in western and central Europe (Gambier 1997; Vlček 1970).

Early Upper Palaeolithic (EUP) skeletal remains which fall outside the range of modern human variability may be interpreted as evidence for substantial gene flow between modern humans and Neanderthals. However, this disparity may also arise if there was a high degree of selection and/or lack of genetic continuity between early Upper Palaeolithic populations and those which followed. The impact of the Last Glacial Maximum (LGM) on Upper Palaeolithic humans is critical to such an interpretation. Global temperatures began to deteriorate after the warmer Hengelo event some 34,000 BP, culminating in the LGM at around 20,000 BP. In the Northern Hemisphere this catastrophic climatic event resulted in massive land-based ice sheets (Boulton *et al*. 2001) and a reduction of sea levels by as much as 130m below their current position (Lambeck 2002; Peltier 1994). Average global air surface temperatures were at least 5ºC lower than modern values. Such climatic changes would present considerable challenges for humans in northern latitudes (see Soffer and Gamble 1990).

The impact of the LGM on human settlement is apparent from the archaeological record. With the exception of possible cryptic refugia (Gamble *et al*. 2004, 2005; Terberger and Street 2002), an archaeological hiatus extends from southern Britain to Poland for up to six millennia. With only a few exceptions, almost no dates occur between the LGM and ~14,000 BP (Terberger *et al*. 2009). Groups living at higher latitudes were forced to move southward. Archaeological evidence points to an influx of immigrants into more southern regions such as Franco-Cantabria, the Balkans, the Italian Peninsula, and the Black Sea littoral zone.

Some researchers have proposed evidence of biological differences between pre- and post-LGM groups. It has been suggested that the harsh LGM conditions may have produced a more cold-adapted body type (Holliday 1997; and see Weaver and Steudel-Numbers 2005 for a more recent discussion). Most obvious here is the sharp decrease in long bone length between pre- and post-LGM populations (Meiklejohn and Babb 2011), with no further change through the Mesolithic, a finding that refutes the earlier suggestion of a reduction in limb length through the post-LGM into the early Holocene (Meiklejohn *et al*. 1984). Changes noted in earlier studies should be treated with some reserve (*e.g.* Formicola and Giannechini 1999; Holliday 1997; Holt 2003; Jacobs 1985; Shackelford 2007). They either relate to issues other than bone length *per se,* or are subject to queries about sampling (including sample size and material used) or methodology. If stature is used as the primary variable, issues arise that include the use of regression equations and the effect of applying different equations for disparate parts of the sample (see discussion in Meiklejohn and Babb 2011).

In contrast with the postcranial skeleton, overall cranial shape variation in modern human populations results from neutral evolutionary forces (González-José *et al*. 2004; Harvati and Weaver 2006; Relethford 2001, 2002, 2004; Roseman 2004; Roseman and Weaver 2004; von Cramon-Taubadel 2009). This correspondence between craniometric and neutral genetic data makes the former a useful proxy for reconstructing population histories. This is particularly important for ancient bones, where issues surrounding contamination and extraction, as well as cost, make DNA studies prohibitive.

Given this background, the aim of this study was to explore the relative variation of Upper Palaeolithic and Mesolithic groups using a subsample (n=76) from a comparatively large craniometric dataset. We use this subsample to assess the craniometric patterns of pre- and post-LGM European Upper Palaeolithic and Mesolithic specimens by testing the hypothesis that EUP European cranial morphology was significantly different to that of post-LGM late Pleistocene and early Holocene populations, as would be expected if the LGM represented a disruption to gene flow patterns within the Upper Palaeolithic. Alternatively, if continuity was maintained through gene flow, we would expect no clear separation between temporally adjacent groups. Hence, this represents the first assessment of the effects of the LGM on patterns of craniometric variation in European late Pleistocene and Holocene populations.

Material and Methods

Archaeological context, chronology and the definition of groups

The compilation of the craniometric dataset, which provides the source material for this study, has been collated from various sources by two of the authors (CM

Martin and Saller (1957) code	Variable
M1	Maximum cranial length
M8	Maximum cranial breadth
M9	Least frontal breadth
M17	Basibregmatic height
M45	Bizygomatic breadth
M48	Nasoalveolar height
M51	Orbital breadth
M52	Orbital height
M54	Nasal breadth
M55	Nasal height

Table 8.1. Measurements used in this study.

and RP) and Winfried Henke. It includes data from the published literature and unpublished measurements by CM and RP as part of earlier work. Our aim was to maximise the size of the dataset, while at the same time using strict criteria to evaluate which specimens would be included. Wherever possible, we used data collected in person by CM and RP. However, published data were used in instances where we did not have access to material.

For the analyses of temporal differences, specimens were divided into four discrete periods: early Upper Palaeolithic (EUP), late Upper Palaeolithic (LUP), early Mesolithic and late Mesolithic. The LGM, dated to ~20,000 BP, was used as the EUP/LUP boundary. In archaeological terms this places Aurignacian and Gravettian material into the EUP, and Magdalenian and contemporary groups into the LUP. The boundary between the LUP and Mesolithic is seen as coeval with the Pleistocene/Holocene boundary. The division between the early and late Mesolithic is more arbitrary in nature. For this study, specimens equal or older than 7000 BP (uncalibrated) were assigned to the early Mesolithic; those younger to the late Mesolithic.

Similar studies in the past were frequently hampered by a lack of reliable dates, with many specimens assigned to the wrong chronological period. Misclassification can seriously bias the results of statistical analyses, particularly in cases where the dataset is small to begin with. The dating and redating of reputed Upper Palaeolithic and Mesolithic skeletal remains behoves us to reassess material from these periods (Trinkaus 2005). We have incorporated the most current dating information in this study. We have only included specimens in our analyses for which the chronological attribution and archaeological association can be reliably determined.

Statistical analysis

Crania were selected from a larger dataset, mentioned in the previous section. Only adult specimens with associated radiocarbon dates or secure provenance were used in the analyses. Ten standard Martin and Saller (1957) craniometric measurements were used (see Table 8.1), corresponding to height, width and length dimensions of the cranial vault and face (including orbital and nasal regions). Specimens missing three or more of these measurements were removed from the original dataset. Multiple regressions were used to estimate missing values (7% of measurements were estimated for the entire dataset).

Cranial measurements were transformed to size-adjusted Mosimann shape variables (Mosimann and James 1979). Darroch and Mosimann (1985) define size as the geometric mean of all variables. Mosimann shape variables were created by dividing each value by the geometric mean of all the variables for each observation.

Sampling methods were used in order to control for the regional bias in the data. For instance, all specimens from Belgium, Britain, Greece, Luxembourg, Norway, Serbia, and the Ukraine were early Mesolithic. Similarly, all specimens from the Czech Republic were EUP, with other EUP specimens restricted to France, Italy, and Russia. Such biases make it difficult to discern whether changes across the LGM were due to different geographic locations being sampled, rather than population disruption at the LGM, as hypothesised. In an effort to control for this factor, analyses were carried out on a sample which was matched by region.

Equal sized samples were chosen for each time period. Since specimens from Russia were only present in the EUP group and not present in any other period, these were removed. The two smallest samples – EUP and LUP – were used as the baseline for choosing the countries to use. Specimens were resampled if they came from the following countries: Italy, France, the Czech Republic, Germany, and Switzerland. A MANOVA was carried out to explore whether significant differences existed in size-adjusted cranial measurements across the four periods. MANOVA requires groups to be relatively equal in size. Unbalanced designs are more likely to violate the assumption of equality of covariance matrices. While Pillai's trace is generally robust to violations of this assumption for samples with equal group sizes (Olson 1974, 1976, 1979), it is not to larger departures (Hakstian *et al*. 1979; Holloway and Dunn 1967). The smallest group (EUP, n=19) dictated the size of the groups. The non-EUP groups were randomly sampled to contain 19 individuals from the above countries. This resulted in a sample consisting of 76 specimens (see Table 8.2).

Period	Country	Specimen	C^{14} BP	Standard Error	Lab Number
Early Upper Palaeolithic	Czech Republic	Dolní Věstonice 3	25950	+630/-580	GrN-18189
		Dolní Věstonice 13	26640	110	GrN-14831
		Dolní Věstonice 14	26640	110	GrN-14831
		Dolní Věstonice 15	26640	110	GrN-14831
		Dolní Věstonice 16	25570	280	GrN-15276
		Mladeč 1	31190	400	VERA-3073
		Mladeč 2	31320	400	VERA-3074
		Předmostí 10	26595	NA	Mean of 2 GrN dates
		Předmostí 3	26595	NA	Mean of 2 GrN dates
		Předmostí 4	26595	NA	Mean of 2 GrN dates
		Předmostí 7	26595	NA	Mean of 2 GrN dates
		Předmostí 9	26595	NA	Mean of 2 GrN dates
	France	Abri Pataud 1	20535	NA	Mean of 10 GrN & 1 OxA dates
		Cro-Magnon 1	27680	270	Beta-157439
		Cro-Magnon 2	27680	270	Beta-157439
	Italy	Barma Grande 5	24800	800	OxA-10093
		Grotte des Enfants 4	NA	NA	NA
		Grotte des Enfants 5	NA	NA	NA
		Paglicci 25	23255	NA	Mean of 2 F dates
Late Upper Palaeolithic	France	Bruniquel 24	15290	150	GifA 95047
		Chancelade 1	NA	NA	NA
		Le Peyrat 5	11430	150	GifA-99117
		Montgaudier 4	11930	NA	Mean of 4 BM dates
		Rochereil	NA	NA	NA
		Rond-du-Barry 1	17100	450	Gif-3038
		St.Germain-la-Rivière 4	15780	200	GifA 95456
	Germany	Oberkassel 1	11570	110	OxA-4790
		Oberkassel 2	12180	110	OxA-4792
	Italy	Arene Candide 1 (EPI)	10450	NA	Mean of 6 OxA dates
		Arene Candide 2 (EPI)	10450	NA	Mean of 6 OxA dates
		Ortucchio 1	12619	410	Pi-23
		Romito 4	10862	NA	Mean of 2 R dates
		Romito 5	11340	NA	Mean of 2 R dates
		Romito 6	11340	NA	Mean of 2 R dates
		San Teodoro 1	14800	NA	Number not known
		San Teodoro 3	14800	NA	Number not known
		Villabruna 1	12140	70	KIA-27003
	Switzerland	Bichon 1	11685	NA	Mean of 2 ETH dates
Early Mesolithic	France	Bonifacio 2	8250	150	Gif-2705
		Gramat 1	NA	NA	NA
	Germany	Birsmatten	NA	NA	NA
		Döbritz 2	8400	50	OxA-10828
		Durrenberg 1	7745	NA	Mean of 1 OxA & 2 Bln dates
		Ofnet 2 (2475 - 4K 1800)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 3 (2476 - 4K 1801)	7520	80	OxA-1573
		Ofnet 4 (2477 - 4K 1802)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 8 (2481 - 4K 1806)	7360	80	OxA-1571

* NA = Not available/not applicable.

Table 8.2. Specimens used in this study (continued overleaf).

Period	Country	Specimen	C^{14} BP	Standard Error	Lab Number
Early Mesolithic		Ofnet 11 (2484 - 4K 1809)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 13 (2486 - 4K 1811)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 15 (2488 - 4K 1813)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 18 (2490 - 4K 1815)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 25 (2497 - 4K 1822)	7515	NA	Mean of 5 OxA & 1 Kn dates
		Ofnet 32 (2504 - 4K 1829)	7560	110	OxA-1575
		Unseburg 1	7670	90	OxA-2918
	Italy	Molara 1	8600	100	OxA-534
		Uzzo 4A	9270	100	Not known
		Uzzo 7	9270	100	Not known
Late Mesolithic	France	Baume de Montclus 1	6665	NA	Mean of MC-695 & MC-728
		Hoëdic 1 (B)	5750	35	OxA-11776
		Hoëdic 6	6280	NA	Mean of 6 OxA dates
		Hoëdic 8 (H)	6080	60	OxA-6707
		Hoëdic 9 (K)	5755	55	OxA-6710
		Téviec 1 (D1)	6510	NA	Mean of 8 OxA dates
		Téviec 2 (B)	6322	40	OxA-12895
		Téviec 4	6510	NA	Mean of 8 OxA dates
		Téviec 6	6510	NA	Mean of 8 OxA dates
		Teviec 7 (K2)	6510	NA	Mean of 8 OxA dates
		Téviec 8 (K1)	6440	55	OxA-6663
		Téviec 9 (K3)	6510	NA	Mean of 8 OxA dates
		Téviec 11 (E1)	6510	NA	Mean of 8 OxA dates
		Téviec 13 (M)	6740	60	OxA-6665
		Téviec 14 (H1)	6515	45	OxA-10963
		Téviec 15 (H3)	6530	60	OxA-6702
		Téviec 16 (K6)	6500	65	OxA-6703
		Téviec 18	6510	NA	Mean of 8 OxA dates
	Germany	Bottendorf 1	5950	80	OxA-2922

* NA = Not available/not applicable.

Table 8.2. continued.

A linear discriminant analysis (LDA) was performed to assess the extent of cranial shape disparity between groups. Mahalanobis squared distances (Mahalanobis, 1936) were calculated to determine the strength of the canonical variates in discriminating between group means. The Mahalanobis distance is a measure for assessing which groups are most different. All LDA analyses were carried out using the MASS package (Venables and Ripley 2002) in R 2.15 (R Core Team 2012).

Post-hoc pairwise MANOVAs were carried out to determine which comparisons were significant for alpha (0.05), adjusted for multiple comparisons. Significance levels were corrected for false positives using the methods of Benjamini and Hochberg (1995). This correction is less conservative and therefore more powerful than family-wise type I error rate corrections of the Bonferroni type.

Given that multiple sources were not available for many of the specimens used in this analysis, inter-observer error was not calculated. However, this factor should be kept in mind when interpreting the results. All data preparation and statistical analyses were carried out in R.

Results

A MANOVA was carried out on the sample. Using Pillai's trace, the effect of time periods on the size-adjusted craniometric measurements was significant (V=0.89, F(3, 195)=2.75, p <0.001). A robust MANOVA was carried out on rank transformed measurements, using the WRS package (Wilcox 2005) in R. As with the parametric MANOVA, a significant effect was found using Munzel and Brunner's (2000) method (F=2.22, p=0.002), and Choi and Marden's (1997) method (H(30) = 85.46, $p < 0.001$).

MANOVA pairwise comparisons across periods were carried out on the untransformed data, while adjusting for false discovery rate. The results are shown in Table 8.3. The EUP sample was significantly different from all other groups in pairwise comparisons. However, the LUP and Mesolithic groups were not significantly different from each other.

The MANOVA was followed by a discriminant function analysis, which resulted in three discriminant functions (Table 8.4). The first function explained 48% of the variance, while the other two explained 30% and 22% respectively. Plots of the first two discriminant functions, together with a separate plot of their mean scores are shown in Figure 8.1. The discriminant function plot shows that the EUP is discriminated from the other groups along the first discriminant function. The coefficients of the discriminant functions revealed that the first function differentiated nasal and orbital dimensions. A similar pattern was also seen for the

Model	Pillai's trace	DF	F	p
EUP vs LUP	0.59	10, 27	3.85	**0.008**
EUP vs EM	0.62	10, 27	4.33	**0.007**
EUP vs LM	0.51	10, 27	2.81	**0.032**
LUP vs EM	0.39	10, 27	1.73	0.124
LUP vs LM	0.46	10, 27	2.26	0.054
EM vs LM	0.46	10, 27	2.31	0.054

Significant *p* values in bold (adjusted for false detection rate)

Table 8.3. MANOVA pairwise comparisons of groups.

Variable	Function 1	Function 2	Function 3
M1	-10.481	-26.128	11.306
M8	-4.048	-42.897	-2.115
M9	-29.370	-45.417	-6.132
M17	-6.077	-32.750	-1.179
M45	-8.778	-34.028	6.228
M48	-16.193	-65.070	14.456
M51	-40.461	-122.416	23.221
M52	-41.740	-157.088	7.789
M54	-77.561	-192.518	37.580
M55	-40.138	-106.668	0.266

Table 8.4. Function loadings of LDA for size-adjusted craniometric data.

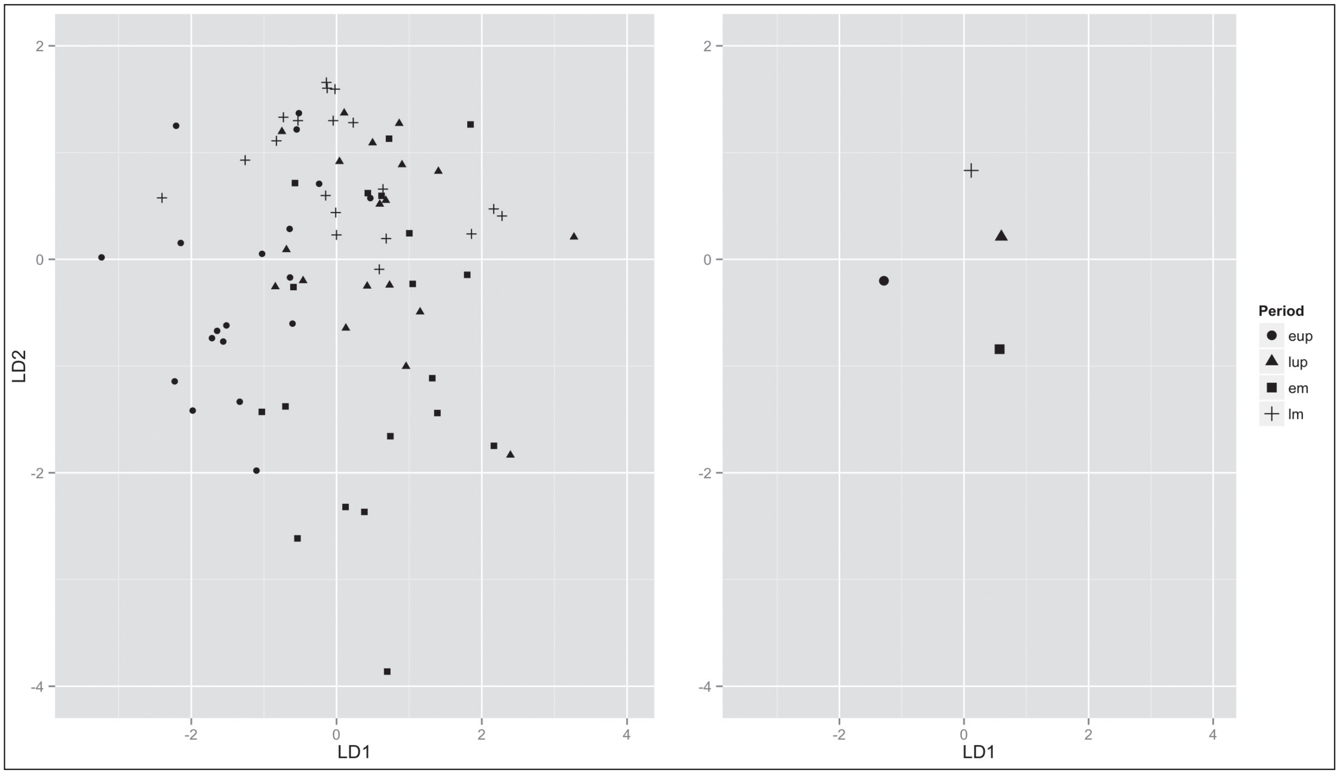

Figure 8.1. LDA plot of specimens and group means.

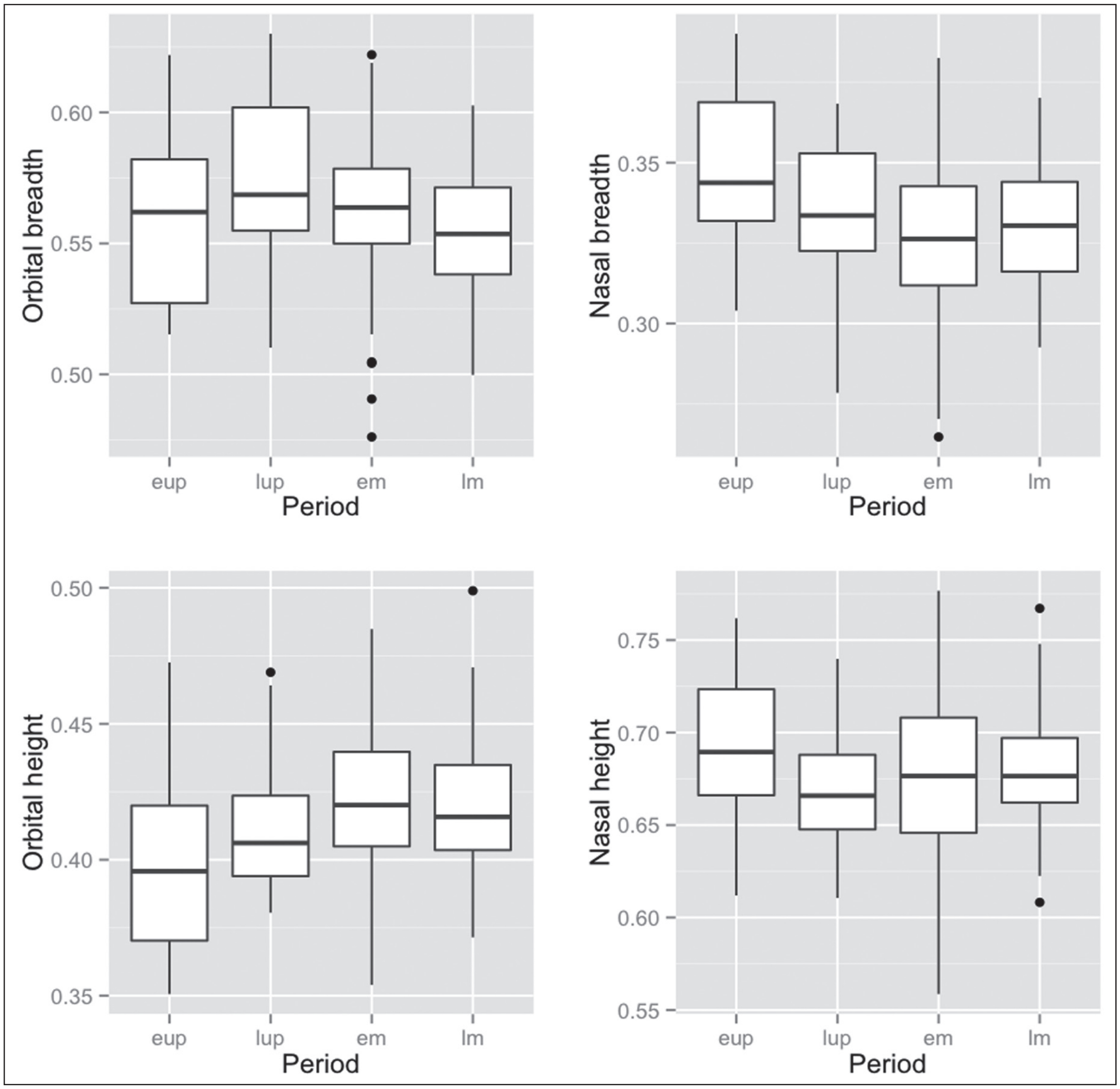

Figure 8.2. Box plots of orbital and nasal measurements.

second discriminant function. Box plot of nasal and orbital height and width measurements are shown in Figure 8.2. The pattern suggests that the EUP group had greater values for nasal dimensions and smaller values for orbital dimensions. The squared Mahalanobis distance between group means was calculated for this sample. These are presented in Table 8.5. Again, the greatest distances were between the EUP and all other groups.

Discussion

These results are similar to those found by Brewster *et al.* (2014), which differed somewhat in its methodology. A MANOVA on a sample matched by geographic location found significant differences across periods. Pairwise MANOVA comparisons found statistically significant differences between the EUP and all other groups, while no significant differences were detected between any of the post-LGM groups. In a linear discriminant analysis, the first discriminant function discriminated between the EUP and all other groups. The Mahalanobis squared distances between the group means was consistently larger for the EUP group. These findings are congruent with the hypothesis that the LGM had a significant effect on European cranial morphology.

The results of the MANOVA and LDA confirm the EUP to be the most divergent group, which is congruent with the hypothesis that the LGM had a major effect on European genetic and morphological diversity.

This study is in line with the conclusions of van Vark *et al*. (2003), who found little craniometric evidence to suggest continuity between EUP populations and more recent European inhabitants (although see Jantz and Owsley 2003 for an opposing viewpoint). Here we propose that the LGM had a significant role to play. Gaps in the archaeological record for much of northern and central Europe suggest that people abandoned these regions at this time and are associated with a marked increase in the number of sites in southern France (Bocquet-Appel and Demars 2000; Bocquet-Appel *et al*. 2005) and Iberia (Straus *et al*. 2000). It is likely that populations survived in relatively small numbers in refugia zones. The relationship in human genetic diversity between refugia would have been affected by drift and founder events. Genetic studies of parental DNA show that many haplotypes were lost during this period, while new mutations arose. Studies of mtDNA (Achilli *et al*. 2004, 2005; Álvarez-Iglesias *et al*. 2009; Forster 2004; Loogväli *et al*. 2004; Pereira *et al*. 2005; Torroni *et al*. 1998, 2001, 2006) and Y chromosomes (Semino *et al*. 2000; Wells *et al*. 2001; Zei *et al*. 2003) have shown a number of haplogroups that likely arose in the Franco-Cantabrian refugium. Evidence for new haplogroups originating in the Balkans (Marjanovic *et al*. 2005; Peričić *et al*. 2005; Rootsi *et al*. 2004) and Ukraine (Peričić *et al*., 2005; Semino *et al*. 2000) add weight to claims that these areas were also important refugia during the LGM (Dolukhanov 2000). Recent studies suggest that the Italian refugium played only a marginal role as a source of genetic diversity in Europe as a whole (Pala *et al*. 2009). In the wake of the LGM, founder groups gradually moved northward to occupy previously deserted areas. These groups would have carried region-specific haplotypes with them.

A limitation of the pan-European approach adopted here is its inability to detect regional patterns of craniometric variation. Although not necessarily reflective of population events, archaeological evidence for continuity across the LGM varies between regions of the continent, as does the sequence of documented technocomplexes. Continuity between the Solutrean and Magdalenian is suggested at some sites with thick stratigraphic sequences in Cantabria, Spain (Aura *et al*. 2012; Straus *et al*. 2012), while changes in bone and antler artefacts (Stettler 2000) may reflect rapid ecological shifts. Some researchers (*e.g.* Banks *et al*. 2011; Ducasse 2012) have proposed a sharp break between the Solutrean and Badegoulian. However, the nature of the latter technocomplex is not fully understood and may have an eastern influence (Gamble *et al*. 2006; see also Kozłowski 2012; Terberger and Street, 2002). In contrast, evidence of continuity can be seen in backed blade or bladelet technologies from the Gravettian into the so-called Epigravettian, in Central and Eastern Europe, as well as the Italian and Balkans peninsulas (Bietti 1990; Mussi 2001). The Epigravettian is largely contemporaneous with the Solutrean through to the Azilian of Western Europe. Mortuary practices in Italy from the Gravettian into the Epigravettian may further hint at continuity (Mussi 1986).

	EUP	**LUP**	**Early Mesolithic**
LUP	4.140		
Early Mesolithic	4.145	2.502	
Late Mesolithic	3.528	2.442	3.040

Table 8.5. Squared Mahalanobis distances between group means.

While there are detectable craniometric differences between the EUP and later groups, it is not clear to what extent these result from neutral evolutionary forces and/or natural selection. The largest loadings for the LDA were on facial measurements, specifically orbital and nasal dimensions, which may indicate climate driven selection (Harvati and Weaver 2006; Hubbe *et al*. 2009; Noback *et al*. 2011; Roseman 2004; Roseman and Weaver 2004). However, von Cramon-Taubadel (2011) found facial shape, including nasal and orbital shape to be congruent with neutral genetic markers. Hence, it is possible that both stochastic effects due to reduced gene flow and genetic drift, and selective evolutionary forces may have contributed to changes in cranial morphology throughout the late Pleistocene.

This study supports the division of the Upper Palaeolithic into two discrete periods separated by the LGM. From a biological perspective the boundary between the Upper Palaeolithic and Mesolithic must be viewed as somewhat arbitrary. A growing number of archaeologists propose that the Mesolithic should be viewed as a continuity of changes dating back to the LGM (Bailey and Spikins 2008). The division of the Mesolithic into early and late is likewise arbitrary. We suggest that studies interested in ascertaining the extent to which modern humans and Neanderthals may have interbred, should only use contemporaneous EUP material. The grouping of specimens from the EUP and LUP into a single ‘Upper Palaeolithic’ category will result in indeterminate findings. Based on the results presented here, the use of a combined LUP and Mesolithic craniometric sample is justified when necessary.

Conclusions

In this study we used a subsample of craniometric data from a larger dataset to explore both temporal and geographic variation in Upper Palaeolithic and Mesolithic populations. This is to date the largest, well-dated dataset for these periods. The EUP showed the greatest divergence in our analyses. This points to the LGM as a disruptive event in the genetic composition of Europe. No clear division between the LUP and Mesolithic was detected, suggesting that the division between the two is arbitrary, at least from a biological point of view. Based on the results presented here we caution against interpreting differences between Upper Palaeolithic populations and recent human populations in Europe as evidence for substantial gene flow between modern and archaic human populations in the late Middle Palaeolithic and early Upper Palaeolithic. The findings of this paper offer testable hypotheses for future studies. A number of alternative explanations exist for the results here. In the interest of space, we have limited ourselves to the discussion of the most parsimonious, ones that are supported by anthropological, archaeological and genetic data.

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9. Funerary Contexts: The case study of the Mesolithic shellmiddens of Muge (Portugal)

Olívia Figueiredo, João Cascalheira, João Marreiros, Telmo Pereira, Cláudia Umbelino and Nuno Bicho

Introduction

The archaeological investigation of shellmiddens has had a long and rich development since those found along the Danish coast in the mid-1830s (Milner *et al.* 2007). However, it is only in the last few decades that the investigation of shellmiddens has become less sporadic and of greater interest, especially with the development of more excavations and the use of new methods. The European Mesolithic has been one of the favored time periods among researchers, mostly because of the challenges that it represents: it was marked by important economic, technological, and social changes that accompanied the last hunters-gatherers in Western Europe, where the Mesolithic shellmiddens of Muge, central Portugal, are located (Bicho 2009; Bicho *et al.* 2010*)*.

Without a doubt, the Mesolithic shellmiddens of Muge, famous for their human burials, had a great influence on the growth of Portuguese archaeology. Along with artefacts like lithics and faunal remains, the estimated 300+ skeletons from this multisite complex makes this one of the most numerous and important collections in the world for the study of Mesolithic society (Bicho *et al.* 2010; Figueiredo 2012; Umbelino 2006). Since their discovery, the work at Muge has been diversified (*e.g.* Cardoso and Rolão 1999/2000; Corrêa 1933, 1934, 1936; Detry 2007; Gonçalves 2009; Monteiro 2012; Newell *et al.* 1979; Paula e Oliveira 1889; Pereira da Costa 1865; Ferembach 1974; Ribeiro 1867, 1884; Roche 1951, 1954, 1957; Roche and Ferreira 1967; Rolão 1999; Rolão *et al*. 2006a, b; Umbelino 2006), but, despite this, we do not know much about the symbolic value of these burials. Although anthropological studies have been at the forefront of the Muge research, the archaeological record has never been properly explored or analysed, which could bring a greater understanding of these Mesolithic populations (Figueiredo 2012). The aim of this paper is to review the available data on the burials and funerary practices and also present new results from recent field work to show how the new methodology and technology applied can change the perception of funerary practices.

The Muge shellmiddens

The Muge shellmiddens, discovered by Carlos Ribeiro in 1863 (Pereira da Costa 1865), are located in Santarém, central Portugal, on the shores of the Tagus River (Figure 9.1). In this area there are more than ten Mesolithic shellmiddens, but unfortunately only two still exist today: Cabeço da Amoreira and Cabeço da Arruda, the former of which is still under excavation. The others were destroyed in the past, though some were partially excavated (Umbelino 2006). In general, these shellmiddens can be described as very large sites (over 2500 m^2 each and between 40 and 80 meters in diameter and 3 to 4.5 meters thick) and located close to the edge of the river margin. They also contain vast quantities of marine and estuarine mollusc shells, disposed as a mound, that display a complex stratigraphy comprising of many archaeological layers. These sites are also marked by the presence of habitat features (*e.g.* hearths, post-holes, pits) and a burial area that are not far from each other (Bicho and Gonçalves in press; Roche 1954, 1972). The two existing mounds (Cabeço da Amoreira and Cabeço da Arruda) are covered by a rock/pebble, human-made horizon that has been interpreted as a way of protection and preservation of the mound (Bicho 2009; Bicho *et al.* 2010; Bicho and Gonçalves in press).

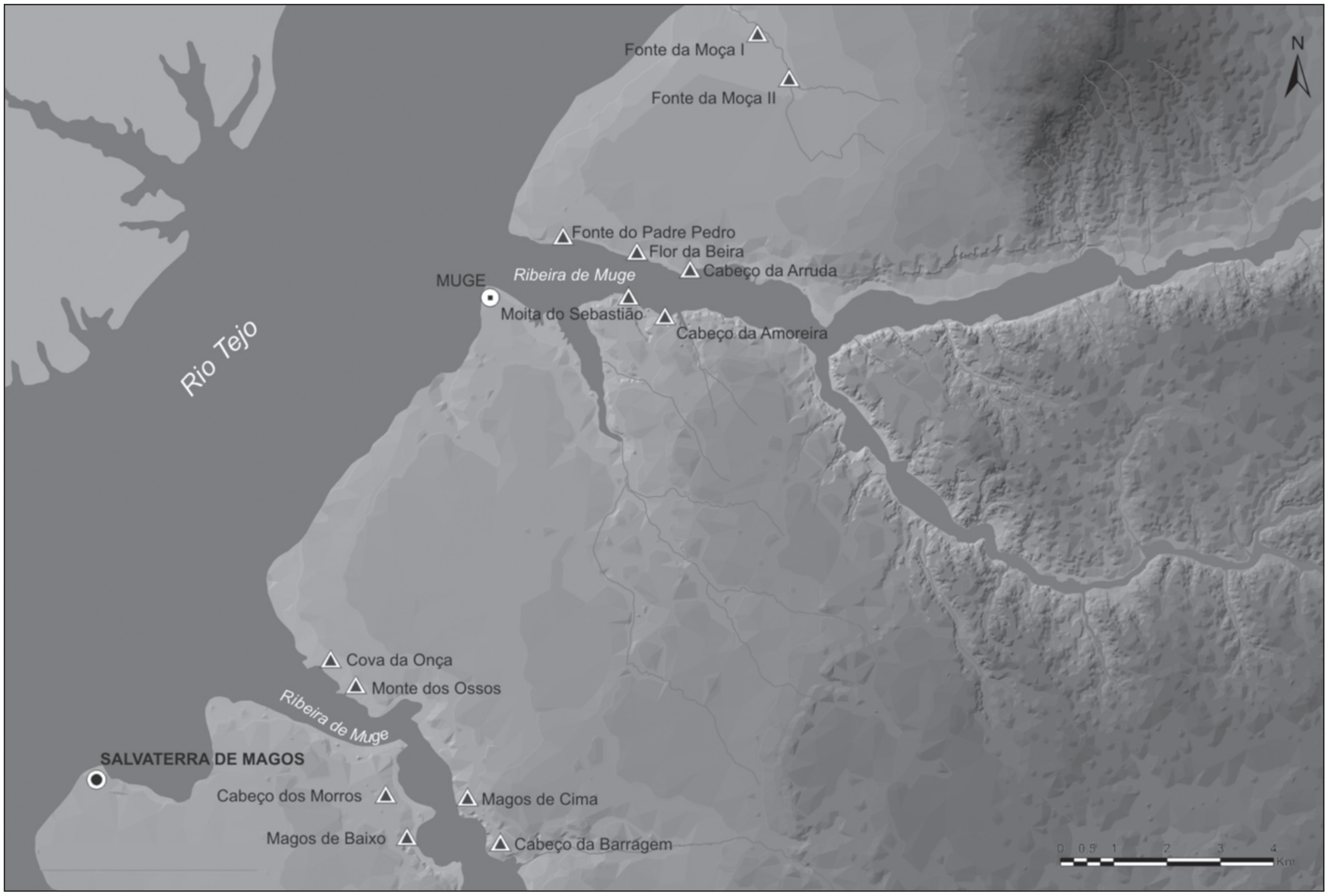

Figure 9.1. Location of the Muge shellmiddens.

The burials – a brief summary of research

The first shellmiddens to be discovered in 1863 were Arneiro do Roquete, also known as Ribeira da Sardinha, and Cabeço da Arruda (Cardoso and Rolão 1999–2000). In that same year, while excavating Cabeço da Arruda, Ribeiro located several other sites: Moita do Sebastião, Cabeço da Amoreira and Fonte do Padre Pedro (Cardoso and Rolão 1999–2000; Rolão 1999). In 1865, Pereira da Costa published the first results from these sites, referring to the discovery of a burial area with at least 45 skeletons and the existence of a significant collection of bone tools, fauna, and lithic artefacts. Once again, in 1884, Ribeiro refers to the presence of more than 120 skeletons in total from Cabeço da Arruda and Moita do Sebastião (Ribeiro 1884). Five decades later, in the early 1930's, a new series of excavations led by Mendes Corrêa (1936) began, resulting in the discovery of several habitat structures and a dozen more burials. In 1937, he also carried out excavations at Cabeço da Arruda, where around twelve more skeletons were discovered (Rolão 1999). In 1952, Veiga Ferreira and Jean Roche began several excavations at Moita do Sebastião, Cabeço da Amoreira, and Cabeço da Arruda, which lasted for several years (Cardoso and Rolão 1999–2000). Another 33 burials were found at Moita do Sebastião (some were collective burials) (Figure 9.2), along with structures (hearths, post holes and storage pits, all in the base of the shellmidden) (Roche 1954, 1972). At Cabeço da Amoreira they also found seventeen more burials and more than ten skeletons at Cabeço da Arruda (Roche 1972). In 2001, while carrying out new excavations at Cabeço da Amoreira, Rolão and colleagues discovered new skeletons (Roksandic 2006). Their aim was to provide more information about the spatial organization of the site and its social organization. Since 2008, Cabeço da Amoreira has been excavated by a team led by N. Bicho within a multidisciplinary project funded by the Portuguese National Foundation (Fundação para a Ciência e Tecnologia).

Most of the Muge burials seemed to have been placed at the base of the shellmiddens, although some were found in the upper layers, as we can see in Cabeço da

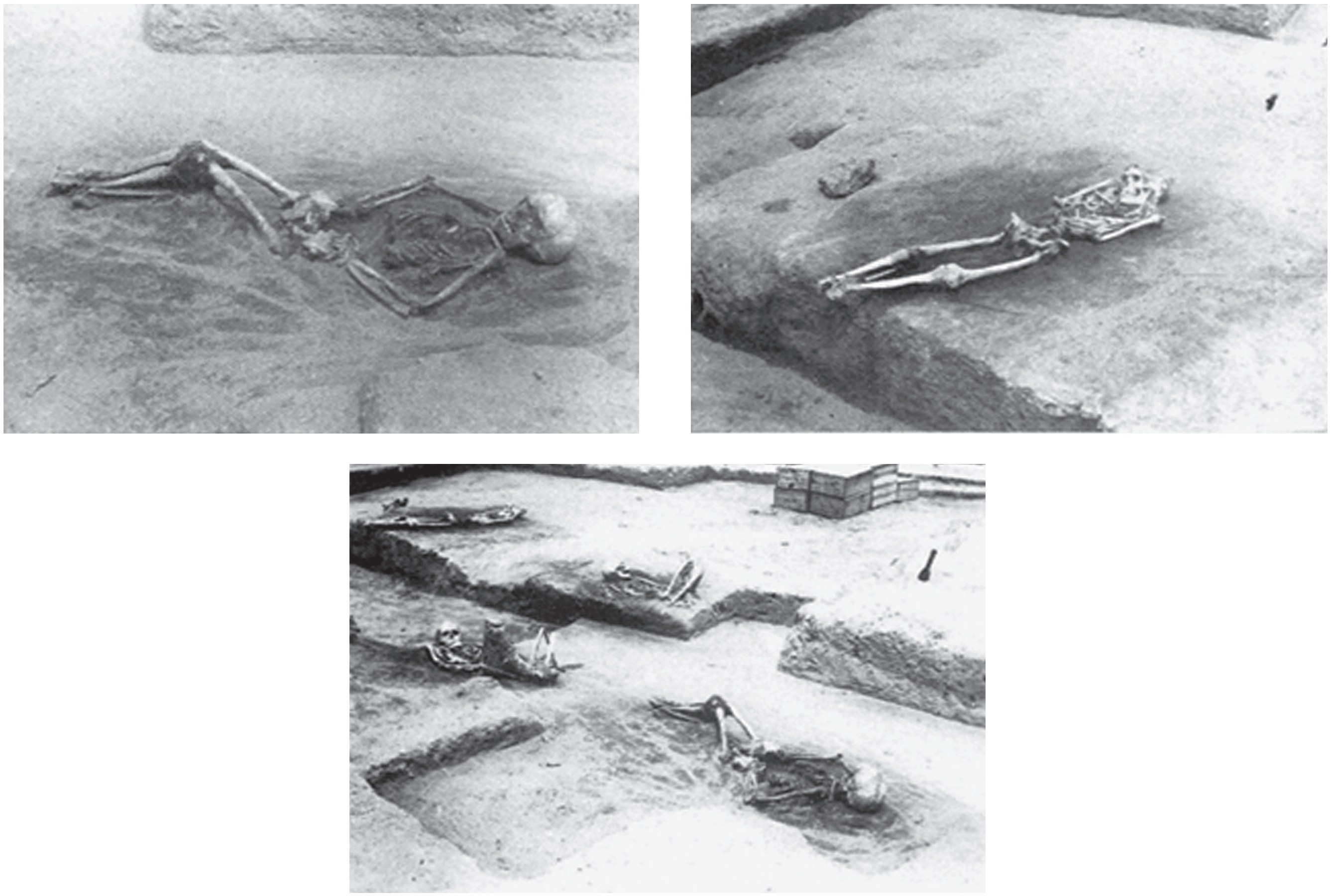

Figure 9.2. Burials from Moita do Sebastião, excavated in 1953. Pictures by C. Teixeira (Cardoso and Rolão 1999/2000).

Amoreira and Cabeço da Arruda (Bicho and Gonçalves in press). Regarding the chronology, the Muge skeletons mostly dated between 7900 and 7250 cal BP, but there are rare older or younger dates (see Table 9.1) (Bicho 2009; Bicho *et al.* 2010; Lubel *et al.* 1986; Umbelino 2006).

The funerary practices

One of the most solid cases for significant funerary practices is Moita do Sebastião, where the burials appear to reveal the existence of small groups, which could be evidence of an incipient social complexity. At the base of this shellmidden several habitat features were found, such as post-holes and pits (Bicho and Gonçalves in press). In this case, above these features were found several burials: 59 adults and 12 children (Bicho and Gonçalves in press; Roche 1952, 1974, 1989). Reanalysis of published data revealed a pattern that might result from intra-site organisation, perhaps deriving from social hierarchy and division (Bicho and Gonçalves in press). The burials are organized into two groups, which are at a distance of more than ten meters from each other (Figure 9.3). In the northeastern group, 22 burials were identified, varying in gender and age. Shells have been found in eight of them, with some perforated (*Theoduxus fluviatilis*) and others not (*Scrobicularia plana* or *Ruditapes decussala*). Four of these 22 burials contained stone artefacts. In the southwestern group, twelve burials were identified, including one of a child. This burial was the only one with grave goods in this area (various perforated fluvial shells of *Theodoxus fluviatilis*). This reanalysis allows an understanding of the differentiation between these burials that could reflect a differentiation in the organization of the Mesolithic inhabitants, at least of this shellmidden. But more than that, this pattern reveals the presence of funerary practices that were not identical for every individual of this population (Bicho and Gonçalves in press).

Analysing the records of previous excavations, it is easy to understand that there was never an established pattern regarding the positions in which the bodies were buried or the votive materials. There

Site	Provenance	Code	Material	Date (BP)	cal. BP 2σ
Cabeço da Arruda	Skeleton 6	Beta-127451	Homo, bones	7550 ± 100	8410–8030
Cabeço da Amoreira	Burial CAM-00-01	TO-11819-R	Homo, bones	7300 ± 80	8015–7695
Moita do Sebastião	Skeleton 22	TO-131	Homo, bones	7240 ± 70	7950–7675
Moita do Sebastião	Skeleton 29	TO-133	Homo, bones	7200 ± 70	7945–7675
Moita do Sebastião	Skeleton 24	TO-132	Homo, bones	7180 ± 70	7935–7660
Cova da Onça	Unknown	Beta-127448	Homo, bones	7140 ± 40	7860–7675
Moita do Sebastião	Skeleton 16	Beta-127449	Homo, bones	7120 ± 40	7833–6745
Moita do Sebastião	Skeleton 41	TO-134	Homo, bones	7160 ± 80	7930–7620
Cabeço da Arruda	Base	TO-10216	Homo, bones	7040 ± 60	7835–7595
Cabeço da Arruda	Skeleton A	TO-354	Homo, bones	6970 ± 70	7835–7575
Cabeço da Arruda	Skeleton III	TO-360	Homo, bones	6990 ± 110	7915–7470
Cabeço da Amoreira	Skeleton 7	Beta-127450	Homo, bones	6850 ± 40	7565–7430
Moita do Sebastião	Skeleton CT	TO-135	Homo, bones	6810 ± 70	7555–7270
Cabeço da Arruda	Skeleton D	TO-355	Homo, bones	6780 ± 80	7660–7425
Cabeço da Amoreira	Multiple burial CAM-01-01 (Base)	TO-10218	Homo, bones	6630 ± 60	7435–7185
Cabeço da Amoreira	Multiple burial CAM-01–01 (Level 2 e 3 – top)	TO-10225	Homo, bones	6550 ± 70	7570–7325
Cabeço da Amoreira	Multiple burial CAM-01–01	Wk-26796	Homo, bones	6329 ± 40	7145–6860
Cabeço da Arruda	Top	TO-10217	Homo, bones	6620 ± 60	7465–7260
Cabeço da Arruda	Skeleton N	TO-356	Homo, bones	6360 ± 80	7155–6735
Cabeço da Arruda	Skeleton 42	TO-359a	Homo, bones	6960 ± 60	7720–7505
Cabeço da Amoreira	Burial 2011.2 (layer 2b)	Wk-32142	Homo, bones	6910 ± 40	7565–7430
Cabeço da Amoreira	Burial 2011.1	Wk-32143	Homo, bones	7132 ± 41	7785–7595

Table 9.1. Radiocarbon dates from the Muge area. Calibrated using OxCal 4.1, based on IntCal09. DR value of 140±40 (Bicho et al. 2012).

does seem to be a tendency to deposit the body in the supine position (lying on the back), varying the position of the arms and legs. It is especially common to observe a dorsal *decubitus* position, with extended arms, flexed knees and the head a little higher than the rest of the body (Figueiredo 2012). Also, individual burials predominate. Although, Roche (1972) refers to a certain tendency to orient the body to the northeast, it is difficult to see a consistent pattern in this.

As said before, the new multidisciplinary project at Cabeço da Amoreira includes a methodology and technology that was never applied to these sites. Excavation by natural layers, subdivided in 5 cm thick spits, and 3D plotting of artefacts bigger than 2 cm using a total station are some of the primary differences in field work compared to the previous excavations of the last 150 years. It is, in fact, a long process, but more information has been retrieved and with much more accuracy. This change has been crucial for the understanding of the structure and the occupation of this shellmidden (Bicho *et al.* 2011). In July 2011, a new burial at Cabeço da Amoreira was found. This individual was a young woman, between 20 and 25 years old. The radiocarbon date gives us a chronology of 7590–7785 cal BP (Bicho *et al.* 2012). The methodology applied was, without a doubt, fundamental for the reconstruction of this new burial.

By having the precise location of each element, it was possible to identify several well preserved layers of shells, lithics, and animal bones that formed the burial. The main difference between these layers and the ones observed in the rest of the excavated area is that the burial was covered mainly by cockle shells (*Cerastoderma edule*), with less sand gaper (*Scrobicularia plana*), which have been analysed by Catherine Dupont (Université de Rennes). So far, we have observed exactly the opposite in the rest of the area that has been excavated since 2008. It is hardly deniable this evidences indicates a precise funerary ritual.

Conclusions

The available studies of the Mesolithic burials from the Muge shellmiddens have been more focused on physical descriptions of the skeletons and other anthropological characteristics, rather than the description of the individual skeleton's position, or burials as seen in the recent work of Roksandic (2006). Other aspects

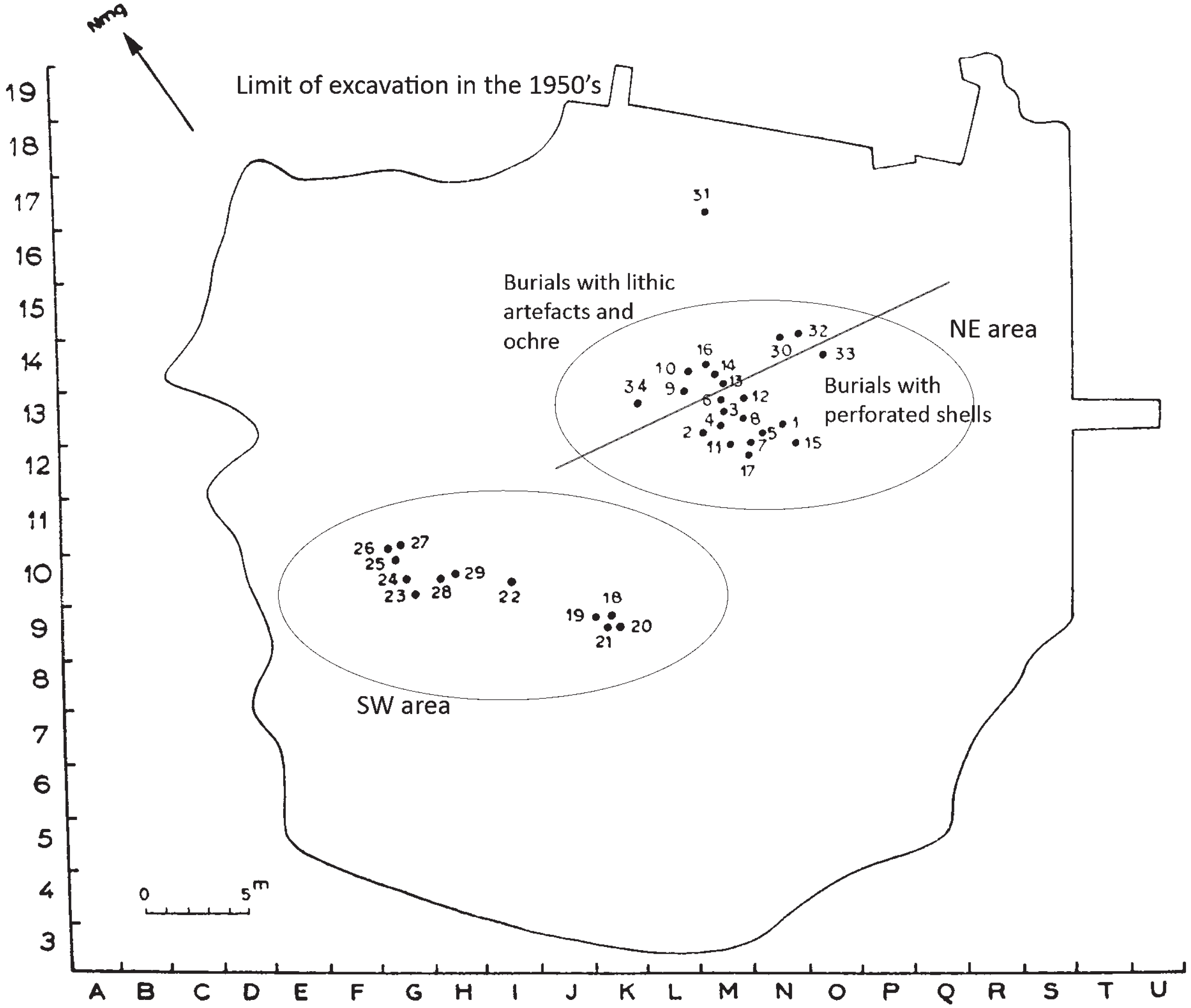
Nmg
Limit of excavation in the 1950's
Burials with lithic artefacts and ochre
NE area
Burials with perforated shells
SW area
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Figure 9.3. Plan of Moita do Sebastião area including the burials (after Bicho and Gonçalves in press).

related to the archeological and cultural contexts are only succinctly referred to. It is essential for the understanding and reconstruction of the burial practices and its importance for these populations, to relate these contexts with the notion of the distribution of the skeletons in the grave and the presence/absence of artefacts, as well as their position. The quality of the records during and after the excavations is obviously essential. These shellmiddens have been periodically excavated since the mid nineteenth century and the methodologies were applied mostly according to the archeological work done at the time. As a result, the quality of documentation has been affected, and is thus a limitation to the reconstruction of this important characteristic of the Muge Valley population. The new methodology applied at Cabeço da Amoreira since 2008 has been essential for a better understanding of the site, and also has great potential for interpreting the funerary contexts and practices, as displayed by the burial found in 2011. This clearly demonstrates that well documented contexts allow for a better reconstruction and interpretation of the burial practices.

There is considerable diversity in funerary practice across all categories of evidences from Muge sites: different body positions, grave orientation, and the variety of grave goods. But there is some providence of possible funerary practices and symbolic acts, as the former of which is still under excavation seen at

Moita do Sebastião, or at Cabeço da Amoreira, with the new discovery discussed above. For now, the only fact easily observed is that these Mesolithic burials are mostly individual, with no defined pattern regarding the position of the body or the artefacts associated to the burial. Nevertheless, the presence of those artefacts, and especially the organisation of the burial area, reveal an intention of interring the dead in a special way.

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10. Fire as a Component of Mesolithic Funerary Rituals: Charcoal analyses from a burial in Cabeço da Amoreira (Muge, Portugal)

Patrícia Diogo Monteiro, João Cascalheira, João Marreiros, Telmo Pereira and Nuno Bicho

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Abstract

A female burial was discovered in Cabeço da Amoreira (Muge shellmiddens) during the 2011 excavation season. This paper presents the charcoal analyses carried out on the charred remains found next to the skeleton, which may help us understand if there was some intention behind the charcoal deposits; primarily using fire as part of the funerary ritual. The results show a predominance of tree wood, especially pine (*Pinus* tp. *sylvestris*, *Pinus pinaster*, *Pinus pinea*). Compared with other environmental data, the charcoal remains from the burial seem to reveal selection of specific wood for this particular context.

Introduction

The economic and social aspect of fire for human societies is easily attested to by the activities linked to, and benefits provided by, the use of this resource, ranging from gathering wood for fuel, to the use of fire for aiding in food processing, lithic knapping, the production of light and heat, and deforestation. In this paper the role of fire will be presented not only in terms of economic matters, but also its contribution to funerary practices during the Mesolithic in Cabeço da Amoreira, based on charcoal analyses from a burial discovered in 2011.

Cabeço da Amoreira is part of the Muge shellmiddens complex in Tagus valley, Santarém, 60 km from Lisbon (Figure 10.1) and is dated to from 8100 to 7500 cal. BP (a table with radiocarbon dates is published in Bicho *et al.* 2012). The site was discovered in 1863 by Carlos Ribeiro and, since then, several archaeological teams have been excavating there (Corrêa 1933; Ribeiro 1884; Roche and Veiga Ferreira 1967; Rolão and Cardoso 1999/2000). More than 300 skeletons have been found in the Muge shellmiddens since its discovery. Although Cabeço da Amoreira could be considered one of the most studied sites from the Mesolithic in Portugal, the work carried out during the nineteenth century and first half of the twentieth century provided limited information and the methodology applied was sometimes problematic, with incomplete and partial recovery compared to nowadays. This point came to be very important in the specific case of the burials, since a lot of information exists about the skeletons from physical anthropological analysis, but not about the funerary context itself (Figueiredo 2012). During the 1990s, a multidisciplinary team lead by José Rolão (Universidade Autónoma de Lisboa) started new excavations in Cabeço da Amoreira. Some important work related to palaeoecological analysis (geomorphological, pollen and charcoal analysis) by T. Van Schriek and team (University of Newcastle, Universidad Autónoma de Madrid e Universidade Autónoma de Lisboa) in the Muge valley was carried out, which was more concerned with the role of the landscape to produce an understanding of the surroundings of Cabeço da Amoreira (Shriek *et al*. 2008; Wollstonecroft *et al*. 2006).

In 2008, a team lead by one of the authors (N.B.) started investigations with a new aim: to understand the subsistence and social complexity of the Mesolithic societies of Muge. This new project involves interdisciplinary studies that help to understand the Mesolithic society of Cabeço da Amoreira through

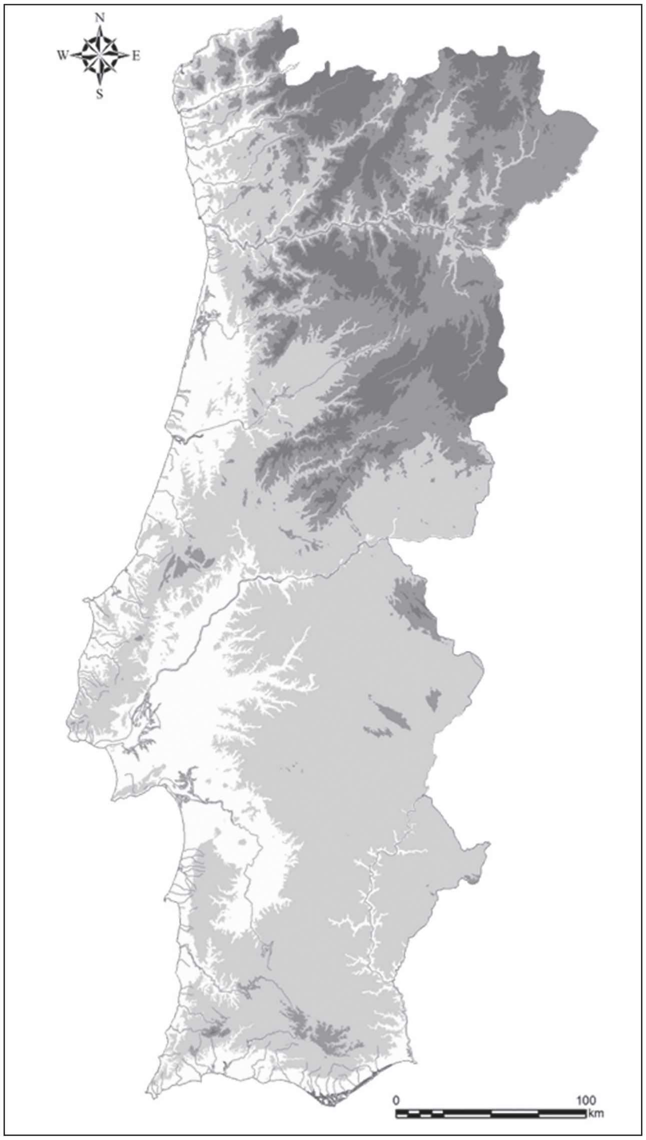

Figure 10.1. Map of the Muge Valley, where the Muge shellmiddens are located.

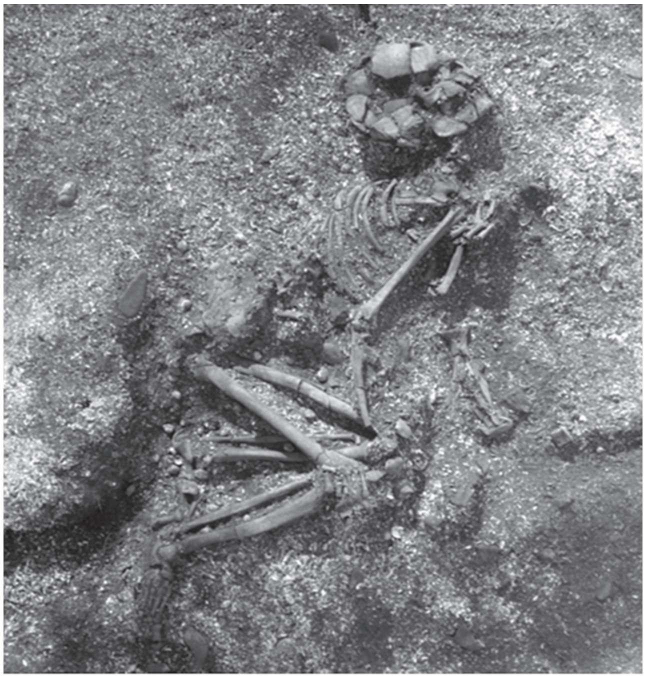

Figure 10.2. The Cabeço da Amoreira shellmidden.

lithic analyses, zooarchaeology, archaeobotany, physical anthropology, DNA analysis, and GIS (Geographical Information System), among others (Bicho *et al*. 2010; Detry 2007; Dias *et al*. in press; Monteiro 2012; Umbelino 2006). Excavation is based on 3D plotting of every piece larger than 2 cm using a total station, allowing very precise information about the provenience of materials and the relation between layers (Bicho *et al*. 2011). This way, upon discovering the burial of a female skeleton in 2011, dated from *c*. 7600 cal. BP (Bicho *et al*. 2013), it was possible to identify several well preserved layers of shells, animal bones, and lithics that covered the body (Figure 10.2). Charcoal fragments were found scattered in these layers, mixed with the shells that formed the matrix. The matrix of shells is different between the burial and the rest of shellmidden area, which was one of the ways used to delimit the burial context (*Scrobicularia plana* forms the matrix in the burial with presence of *Cerastoderma edule*, while the reverse occurs in rest of the midden). The provenance of the charcoal is frequently difficult to determine; the primary deposition most of the time could only be caused by a combustion structure or similar. Nevertheless, in the case of the female burial, we have reason to believe that charcoal was brought in to the context and was not introduced by casual deposition, as there is no evidence of disturbance of the layers, and those that cover the skeleton, along with the skeleton itself, appear defined and intact. This leads us to assume that the charcoal came from a purposeful disposal as part of the burial. However, even though the burial presents clear evidence of some kind of funerary ritual, it might be risky to consider the use of fire *in situ* with ritual purposes, as there is no indication of burnt materials that might suggest a conflagration. Thus, charcoal analysis could be an important method of ascertaining which vegetal species were present, or might have been used in this context and whether some kind of selection bias was present.

Materials and methods

This study of fire in funerary rituals is based on charcoal analyses from burial number 2. Charcoal fragments

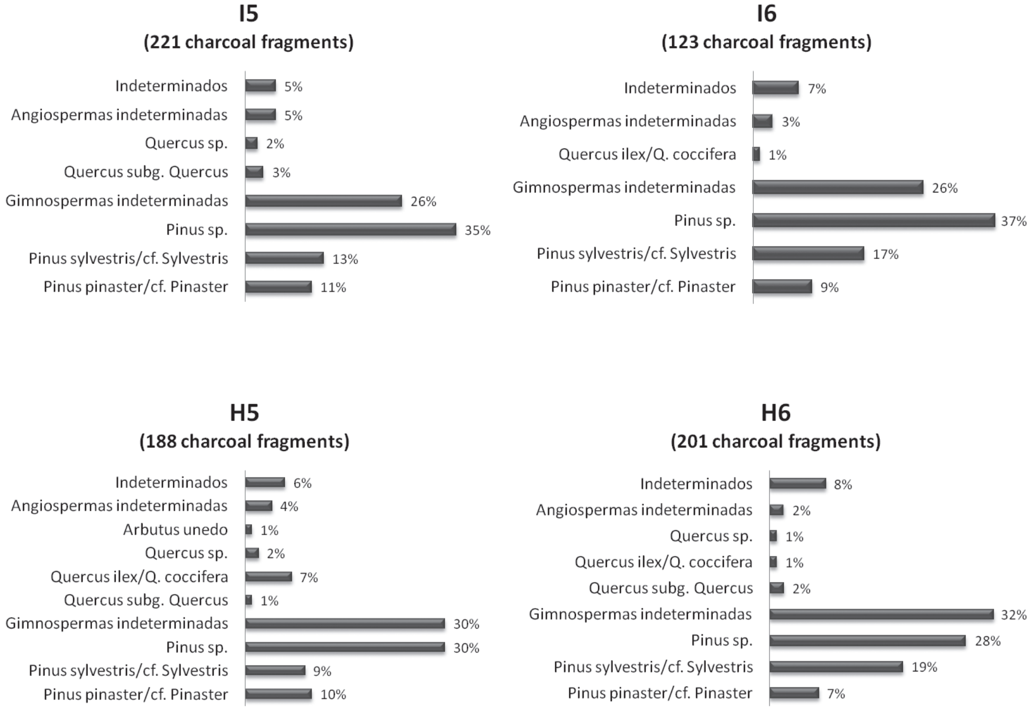

Figure 10.3. Results from the charcoal analyses from Burial 2.

Species	**North Profile**	**Burial**	**Open area**
Pinus sp.	256	236	27
Pinus cf. *pinaster*	131	66	-
Pinus cf. *zinaster/pinea*	42	-	-
Pinus sylvestris tp.	13	103	-
Gymnosperm	234	207	18
Quercus subg. *Quercus*	2	9	3
Quercus ilex/Q. coccifera	10	18	6
Quercus sp.	3	-	-
Arbutus unedo	-	1	-
Angiosperm	19	25	5
Indeterminate	85	61	14
Total	795	733	73

Table 10.1. Results from the charcoal analyses. Identified taxa from Burial 2.

were recovered by flotation, the recommended method for recovering of paleobotany remains (Alonso *et al.* 2003), and fragments larger than 2 cm were plotted to assure their spatial distribution. The burial occupied four squares within the excavation area: I5, I6, H5 and H6. The same amount of sediment was retrieved from each square for flotation; approx. 900 litres. The smaller pieces of charcoal came from around the head the skeleton.

After laboratory processing, a total of 733 charcoal fragments larger than 2 mm were separated for analyses. All the charcoal fragments were observed in the three main sections (transversal, longitudinal tangential and longitudinal radial) to identify the species using a reflected light microscope. The species identification was made by comparison with a reference collection of modern charcoal and wood anatomy atlases (Garcia Esteban, 2002; Schweingruber, 1990; Vernet *et al.* 2001).

Results

From the 733 charcoal fragments observed the following species were identified: *Pinus* cf. *pinaster*, *Pinus* tp. *sylvestris*, *Quercus subg. Quercus*, *Quercus ilex/coccifera* and *Arbutus unedo.* Table 10.1 displays the representation of each taxon in the assemblage. Pine is clearly the most abundant, with a total of 91%. Angiosperms represent 9% of the sample, corresponding to a total of only 60 fragments. As we observed the spatial distribution of the materials, it is interesting to present the data from each of the squares that make up the burial (Figure 10.3). There is no significant difference between each square. Even so, a slight distinction could be noted in the distribution of *Quercus*. This species is present in every square, but evergreen *Quercus* is represented in higher quantities in H5, while in I5 and H6 more

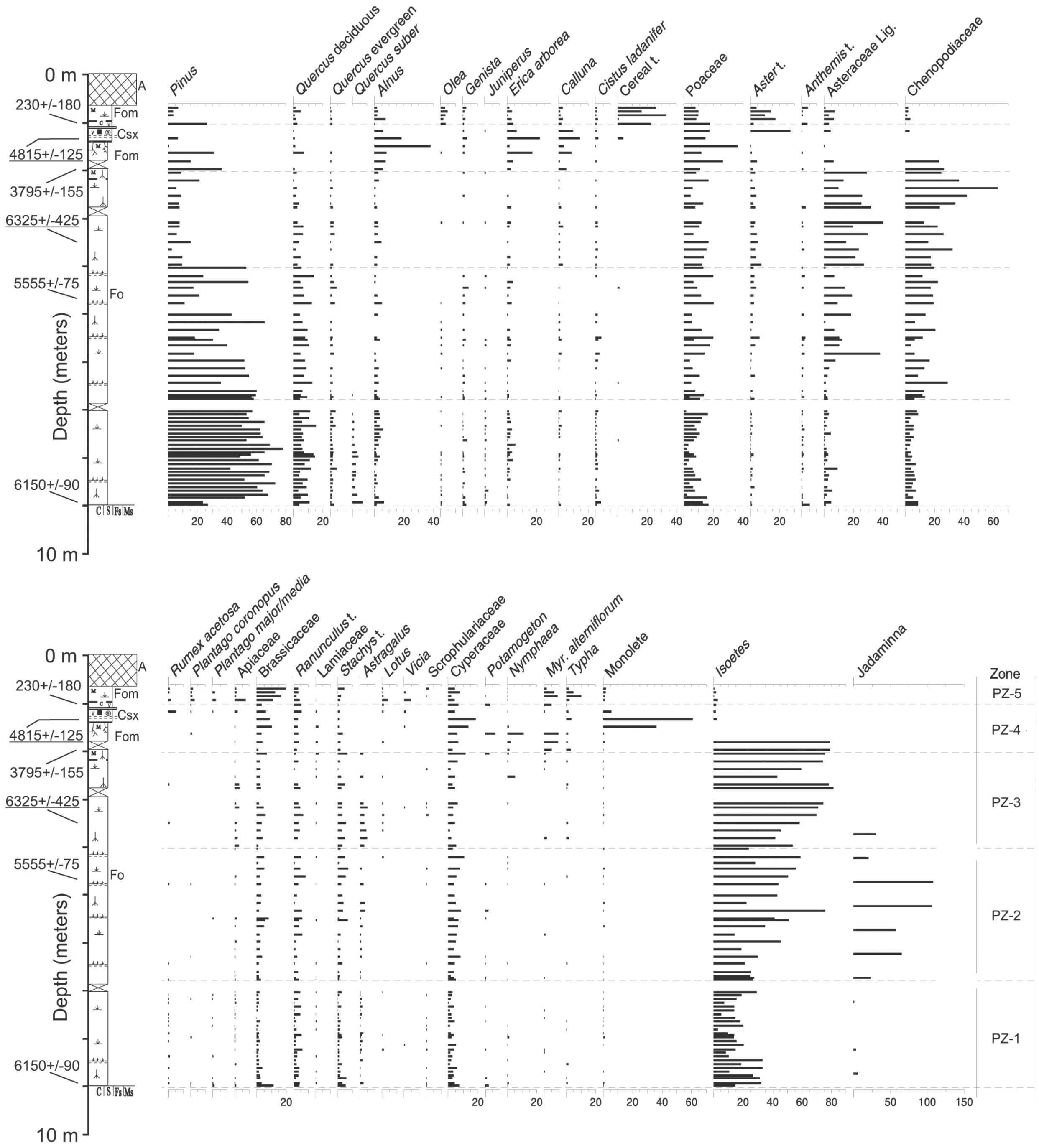

Figure 10.4. Pollen diagram based on a core from the Muge Valley bottom (after Schriek et al. 2008).

deciduous *Quercus* is present. The presence of *Arbutus unedo* records the only example of bush wood within the assemblage, with one single fragment in square H5.

Discussion

Paleoenvironmental data from previous studies, such as pollen and charcoal analyses (Monteiro 2012; Van der Schriek *et al*. 2008; Wollstonecroft *et al*. 2006), that could provide paleoecological and subsistence information, are fundamental tools to provide a comparison with our present data, and for further interpretation. The main results of these studies will be presented here to compare with the charcoal from the burial.

The pollen diagram by Franco Mugica (in Schriek *et al*. 2008, 145, see Figure 10.4), based on the analysis of

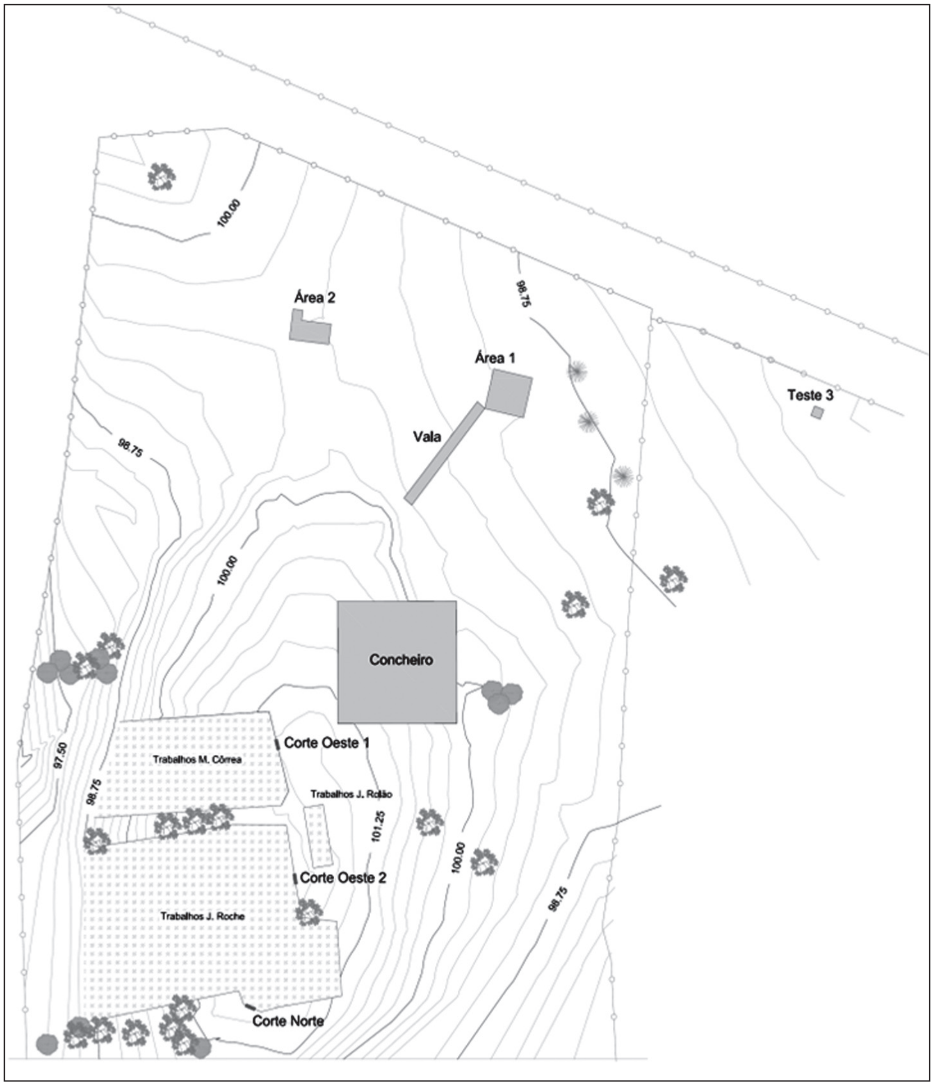

Figure 10.5. Plan showing the extent of excavations across Cabeço da Amoreira where charcoal analyses have been carried out.

a core from the Muge valley bottom, reveals an open landscape between 8000 and 6000 cal. BP (corresponding to pollen zone 2). Pollen zone 2 is contemporary with the burial under study and is composed mostly of shrub vegetation, with some tree vegetation (*Pinus*, deciduous and evergreen *Quercus* and *Alnus*). Although this data displays a variety of available shrubs, in the charcoal results this type of wood is not predominant. In fact, the only evidence of bushes is from a fragment of *Arbutus unedo*, which, although a shrub, can reach the size of a tree. The relevance of tree wood in this context, within an environment rich in other sources of wood, especially from shrubs, might indicate preferential selection of wood.

The same happens in other contexts from Cabeço da Amoreira where charcoal analyses have been carried out (Figure 10.5). The charcoal from the North profile and the shellmidden area with scattered origins present similar results. Based on the assumption that charcoal results from a human interaction with the environment and partially reflects a social characteristic of human activity, we might better understand the selection of some of the available wood species in the Muge landscape. The predominance of *Pinus* and presence of evergreen and deciduous *Quercus* in all of the contexts studied indicates a possible preference for this kind of wood. This hypothesis is also supported by the efficiency of using the wood of both species together, due to pine's property of being easy to burn and oak's characteristic of maintaining a fire.

Comparing the two different contexts (one funerary, the other contemporary and non-funerary), there is a distinction between the results through the appearance of a rare species within the charcoal, the wood from the wild strawberry bush, *Arbutus unedo*, and by the significance of *Pinus* tp. *Sylvestris* within the burial. *Pinus* tp. *sylvestris* is frequently associated with colder environments. In the Holocene this species had begun to decline with the arrival of more thermophilous species such as *Quercus*. In Figure 10.4 it is possible to see the relevance of each pine species represented. The importance of *Pinus* tp. *sylvestris* in the burial, with 131 charcoal fragments (61% of the total), is clearly displayed. Using the strawberry tree (*Arbutus unedo*) for its fruit can be considered, but the fact that there is only one fragment, as well as the unclear question of the charcoal's deposition, does not allow for confirmation of this hypothesis. The choice of a specific type of wood as fuel for this funerary context is one hypothesis that can be reinforced only by the results from Cabeço da Amoreira, and the differences between contexts. Despite the fact that preservation of the burial and the lithics, fauna, and adornments that covered the skeleton, which are still under study, might lead us to think that the charcoal remains were also part of the funerary ritual, we must note that the charcoal deposition process is more complex than for other materials. Even if it is not possible to assume the existence of a fire *in situ*, we believe that, since the deposition of layers appears undisturbed, the charcoal within might have been a secondary deposition. This also seems to be confirmed by the differences in species, as well as their relative importance, when compared to the rest of the samples. In this case, charcoal analyses are necessary for helping clarify this occurrence.

Conclusions

The charcoal analyses of the remains from the burial reveal the presence of the following species: *Pinus* tp. *sylvestris*, *Pinus pinaster*, *Quercus ilex/Q. coccifera*, *Quercus* subg. *Quercus* and *Arbutus unedo*. These taxa also appear in other contexts within Cabeço da Amoreira, though in different frequencies. The only exception is the wild strawberry tree (*Arbutus unedo*) present in the burial.

Even if is too early to assume that these results are evidence of purposeful selection of specific types of wood for the funerary ritual, it is interesting to verify the differences in the contexts studied and consider the total absence of *Arbutus unedo* in other areas of the shellmidden, as well as the significance of a less frequent species in within the landscape. However, the absence of *Arbutus unedo* is based on around 1000 charcoal fragments from two other non-funerary contexts from Cabeço da Amoreira. Therefore, only further charcoal analysis from different areas of the shellmidden, whose chronology and context are well defined, can provide more information that is able to help us understand the importance of fire in these contexts.

The intentional use of fire could not be absolutely confirmed, but, based on the available plant resources in the Muge valley landscape at the time of the burial, it seems that a few specific types of wood are present in the funerary context. The same happens for other contexts within the shellmidden, but, even when compared, this burial presents some distinctions from the non-funerary contexts, notably the predominance of *Pinus* tp. *sylvestris* and presence of the wild strawberry. This fact, together with the evidence of funerary ritual, makes us consider the hypothetical use of specific types of wood, with special properties for burning, within this burial. To be confirmed, this hypothesis needs further investigation. More charcoal and other archaeological analyses need to be carried out for the different contexts of Cabeço da Amoreira, which will help us understand more about the role of fire within Mesolithic society.

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11. Animal Magic: The discovery of Upper Palaeolithic Parietal art in Cathole Cave, Gower Peninsula, South Wales

George Nash

Abstract

The discovery of an engraved cervid, probably a reindeer, in September 2010 within an inland cave known as Cathole on the Gower Peninsula has reaffirmed the presence of hunter/fisher/gatherer communities in this area of Britain during the Late Upper Palaeolithic. The discovery of a probable engraved figure within a niche located at the rear of Cathole Cave suggests that hunter/fisher/gatherer communities used this section of the cave for ritual purposes. The figure, with a clearly defined torso, legs, and antler set, was produced using a flint tool. The contrast between the straightness of the engraved lines and the curved surface of the flowstone into which it has been carved eliminates any possibility that the figure is a chance configuration of natural fractures. The engraving is the first of its kind to be found in Wales and only the second confirmed discovery of parietal art in the British Isles. In April 2011, samples were taken from a secondary mineral deposit – speleothem (stal) – for Uranium Series dating; a section of this deposit stratigraphically overlay the rock art and the surface on which it was engraved, which provided a minimum age for the engraving.

Introduction

Based on the climatic and environmental records, the British Isles has tended to be regarded as an Upper Palaeolithic cultural backwater, with little or no human activity recognised in the archaeological record, especially during the Late Devensian (*e.g.* Darvill 2010; Wymer and Bonsall 1977). This lack of evidence is due mainly to the fact that most of Britain was covered by an extensive ice sheet between 40,000–12,000 BP, with the glacial maximum occurring around 22,000 cal. BP. Based on oxygen isotope analysis though, this cold stage lasted for around 100,000 years, from 110,000 to 10,000 years ago. The southernmost limit of the Welsh ice margin extended to just a few kilometres north of Cefn Hill, an upland area that extends across much of the Gower Peninsula in South Wales. The landmass in front of the ice margin, which included the present landform of the peninsula and an extensive area of floodplain that is now the Bristol Channel, can be described as permafrost tundra-steppe formed as a result of pro- and periglacial activity (Figure 11.1). During the summer months this landscape would have offered megafauna, such as bison, elk, horse, mammoth and reindeer a rich seasonal feeding ground. It is conceivable that the present coastal zone of South Wales, from the Wentlooge Levels in the east to the rugged hills around Ammanford in the west, also constituted an ideal breeding area for such megafauna during the summer months.

In general terms, and according to Barton (1997) and Lowe and Walker (1997), the climatic and environmental picture is extremely complex. If the engraving, which I believe represents *Rangifer tarandus*, was created shortly before the formation of a covering stal deposit, then it and the stal probably formed within the Last Glacial Maximum, a period characterised by rapid warming followed by rapid cooling and a consequent resurgence of ice. During this time, the British Isles witnessed changes in the faunal record that place and date the reindeer engraving either during or before the Loch Lomond Stadial.

Prior to the onset of this interstadial, small groups

Figure 11.1. Current view of the Bristol Channel, looking south-west from Bacon Hole (photograph by George Nash).

of hunter/fisher/gatherers appear intermittently to have colonised northwestern Europe, moving north and west along the resource-rich valleys. This pioneer phase is based on a limited number of radiocarbon dates that serve to chart these migration channels – albeit tentatively – in chronological terms (Housley *et al*. 1997). At around 13,000 BP, the climate began to warm, probably eventually attaining temperatures one to two degrees higher than present. Based on what amounts to a limited archaeological assemblage, tangible human reoccupation in Britain appears to commence around 12,600 BP, some 500 years after the colonisation of lands that are now France and Belgium.

Geomorphology of the cave

Cathole Cave, in which the reindeer engraving was discovered, stands at about 30 m above sea level on the northeast side of a dry limestone valley, approximately 2 km north of the present coastline (Figure 11.2). It comprises two principal components: a wide passage with a largely flat undulating roof and tall, narrow, joint-influenced rifts that rise several metres above the general roof level (Simms 2011). In plan, the cave has two entrances: the southern entrance leads to a large low-roofed gallery extending about 11 m to the north-east (Figure 11.3). Either side of the main gallery are side-chambers; the northern side-chamber diverts westwards to an antechamber and, beyond this, a second blocked entrance (Oldham 1978). To the northeast of the main gallery is another gallery that extends a further *c*. 8.3 m (Figure 11.4). This section of the cave is difficult to access and, as far as the author is aware, has never been fully investigated until recently.

In early 2011, the accessible section of the cave was surveyed using 3D laser technology. The purpose of this part of the project was to provide a detailed set of 3D images of the cave (Nash and Beardsley 2013). Subsequent data has enabled the team to produce an accurate floor plan, which was produced using nine laser scan targets that were positioned at key positions within the cave (Figure 11.5). The laser scanning identified a number of natural anomalies that could not be mapped using conventional survey equipment, in particular the contour complexity of the roof and the relationship between the main gallery and the various side niches.

The rugged surface of the roof suggests that the gallery was formed originally in a phreatic environment, *i.e.* the cave was below the water table and entirely water-filled (Simms 2011). The rock floor of the cave is concealed by a largely unknown depth and type of

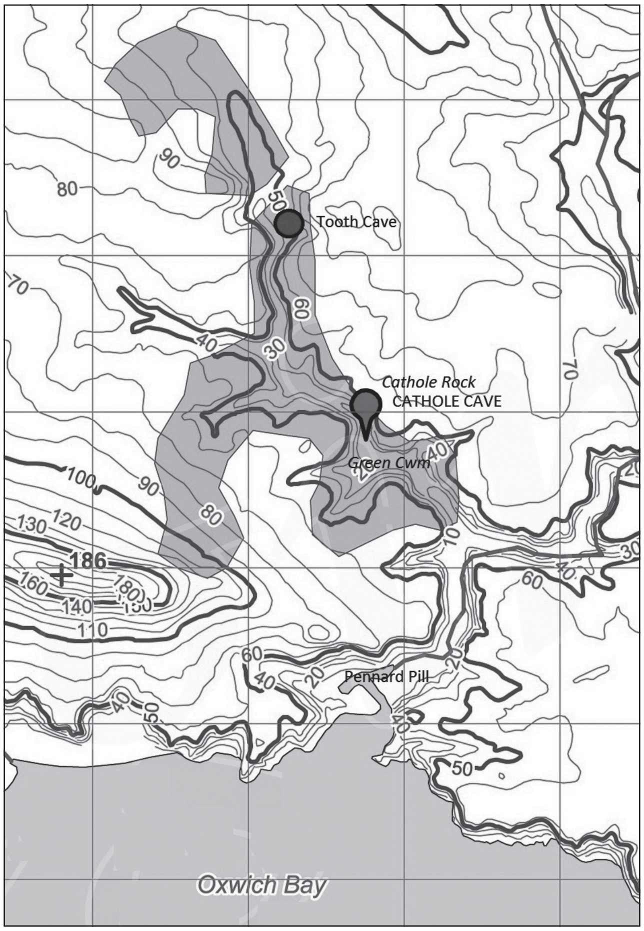

Figure 11.2. The Location of Cathole Cave, Gower Peninsula.

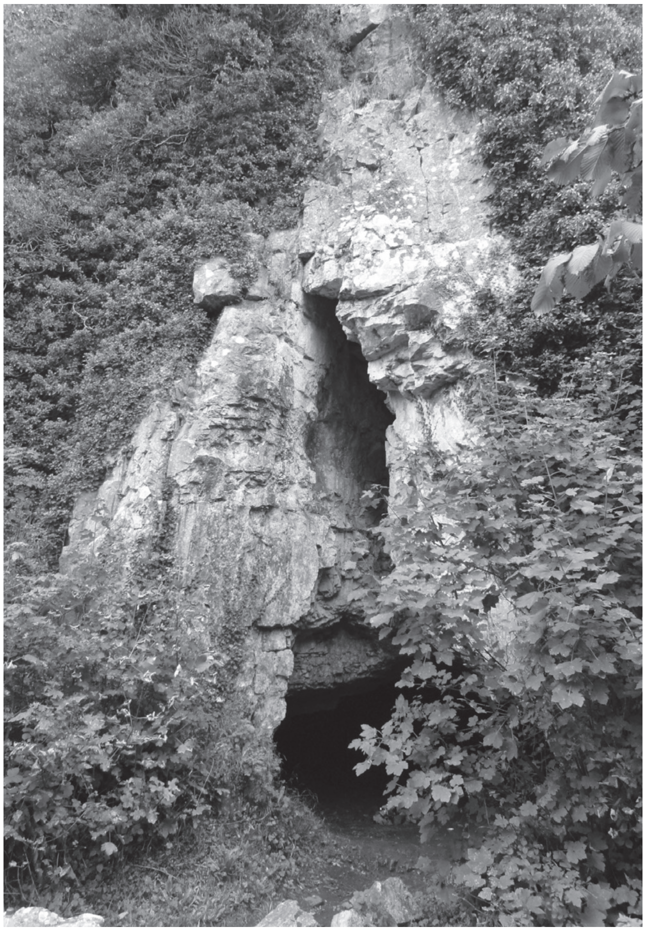

Figure 11.3. The entrance to Cathole Cave.

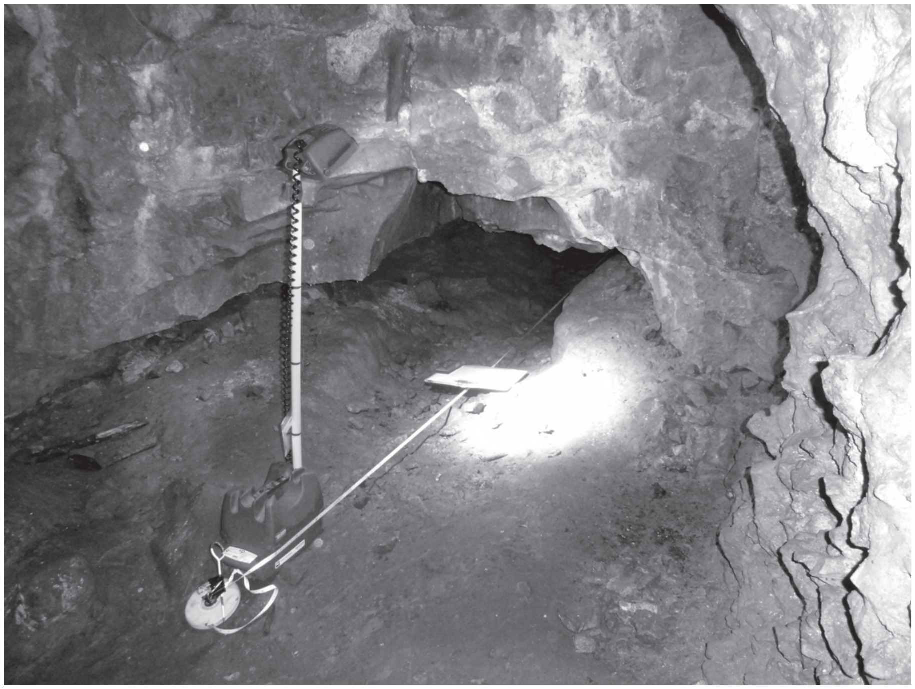

Figure 11.4. Small opening leading to the north-eastern section of the cave.

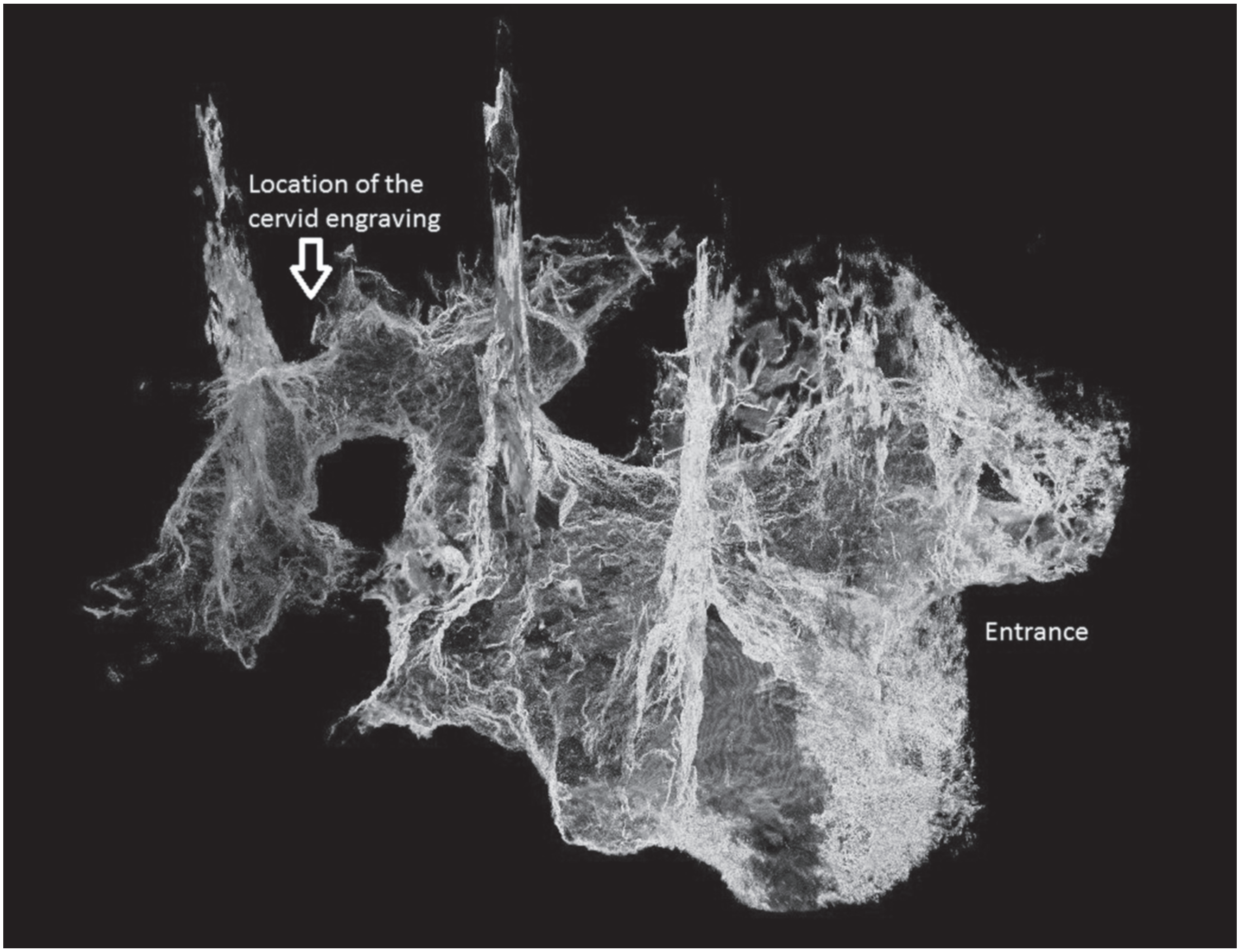

Figure 11.5. Isometric image of the main gallery.

sediment. Discoloration of the lower part of the walls within the main gallery suggests that the excavations undertaken by Colonel Wood in 1864 removed between 0.7 m and 1 m of this sediment fill.

The cave today stands at about 15 m above the valley floor, with the present day phreas probably 5 m or more below this. Hence the cave appears to have formed in a landscape very different from what we see today. The current V-shaped Parkmill Valley probably did not exist at that time, the valley floor being tens of metres higher than today and extending above the current roof level of the cave (Simms 2011). It is possible that the various water-worn relict passages of the cave represent the remnants of a former subterranean river system or sub-valley drainage system that was in operation when the valley floor was higher. The subsequent incision of the valley to its present level may be the result of erosion by glacial meltwater runoff during periods when periglacial conditions prevented significant subterranean flow (Waltham *et al*. 1997). The stream originally flowed through the Parkmill Valley but now resurges at the southern end of the valley, close to the settlement of Parkmill, before reaching the sea. Amelioration of the climate and lowering of the phreas caused the surface flow to sink progressively further north in the valley. The present stream sinks at Llethrid Swallet, located to the north (Ede and Bull 1989). Under flood conditions this swallet may be unable to accommodate the full flow, causing ponding and creating a surface stream that may continue a little further south to sink at older swallets a metre or two higher.

Based on the amount of frost-shattered stone both above and below the surface, the cave entrance may perhaps have extended a further 3–5 m westwards towards a pronounced tongue formed from thermoclastic(?) scree which includes probable spoil from the nineteenth century excavation of Colonel Wood (see below).

Faunal Remains from the Wood Excavation (after Garrod 1926, 65)	**Faunal Remains from the McBurney Excavation (after McBurney 1959, 268)**
Arvicola sp.	*Bos sp.* (teeth)
Canis vulpes	*Capreolus capreolus* (mandible)
Cervus elaphus	*Cervus elaphus* (phalanges, metatarsal, calcanaeum)
Cervus megaceros	*Equus* (tooth)
Elephas primigenius	*Lemmus lemmus* (mandible)
Equus caballus	*Lepus cf timidus* (radius)
Felis spelaean	*Meles taxus* (various bones and teeth)
Felis catus	*Ovis sp*. (teeth)
Hyaena spelaean	*Rhinoceros sp.* (tooth)
Rhinoceros tichorhinus	*Rhinoceros tichorhinus Ursus cf arctos (incisor)*

Table 11.1. List of species from the Colonel Wood and McBurney excavations.

Excavation history of the cave

Cathole Cave has been the focus of a number of investigations over the past 150 years (summarised in Green and Walker 1991). The first of these was undertaken around the upper cave floor in 1864 by a Colonel E. R. Wood, who recovered a small assemblage of flint tools, metal implements, and pottery dating to the Bronze Age, as well as a significant Pleistocene faunal assemblage (Table 11.1).

In 1958, within the entrance area of the cave, the seasoned archaeologist Charles McBurney of Cambridge University excavated four small rectangular trenches. Recovered from this excavation was a significant lithic assemblage; a limited number of the items being diagnostically similar to flint blades and points found at other Creswellian sites at Creswell Crags and Cheddar. In addition to the Late Upper Palaeolithic assemblage, two tanged Font Robert points were identified as dating to between 22,000 and 28,000 years BP, suggesting a much earlier occupation. This assemblage, together with McBurney's notes and plans, are archived in the National Museum of Wales (Elizabeth Walker pers. comm.). In his paper, McBurney (1959) gives a useful summary (based on Garrod 1926) of the faunal assemblage recovered by Colonel Wood during his 1864 excavation (reported in Roberts 1887). Despite the lack of any stratigraphic record and the survival of a 'handful' of white patinated flints that appear to have been of 'Creswellian type', Wood's excavation did recover a unique faunal assemblage (McBurney 1959, 265). According to Garrod (1926, 65), this assemblage was given to the Natural History Museum (Table 11.1).

According to Garrod's account, Wood excavated the 'upper cave' (main gallery) and she notes that much of the "contents of the cave are mixed" (*ibid.*, 66). Also retrieved from his excavation were a number of Holocene artefacts, including a hammer-stone, a bronze axe (or celt), pottery fragments, and a selection of flint tools, suggesting occupation of the cave for at least 26,000 years. Possibly within this later stratigraphic context were the bones of (domesticated?) goat, pig and sheep, as well as possible evidence of two later prehistoric human burials. However, the Pleistocene faunal assemblage from both Wood's and McBurney's excavations is represented principally by extinct fauna (Table 11.1). Despite the absence of chronometric dating of these remains, the presence of such animals indicates a changeable climate, probably coinciding with the interstadial and stadial regimes between 13,000 and 11,000 years BP. Following McBurney's investigations, a small excavation was undertaken by John Campbell in 1968, which largely substantiated McBurney's stratigraphic interpretation, although Campbell (1977, 58) did recognize later material, which was probably Mesolithic in date. Campbell opened his trenching to the south of McBurney's excavation and arguably within an area of peripheral prehistoric activity (*i.e.* originally within the southern part of the cave entrance). Despite recovering only a limited number of finds, Campbell recognised two important phenomena. First, the various periods (supported by diagnostic flint) appeared to be separated by intermittent thermoclastic activity (frost-shattered scree, suggesting several cold episodes). Secondly, and little discussed in the McBurney report, was the presence of a clear Mesolithic horizon from which a handful of lithics were recovered. Unfortunately, the bone fragments and charcoal recovered from the Lower Open Thermoclastic Scree (LOB) and Middle Sandy Thermoclastic Scree (MSB) layers (both Late Upper Palaeolithic) were then considered

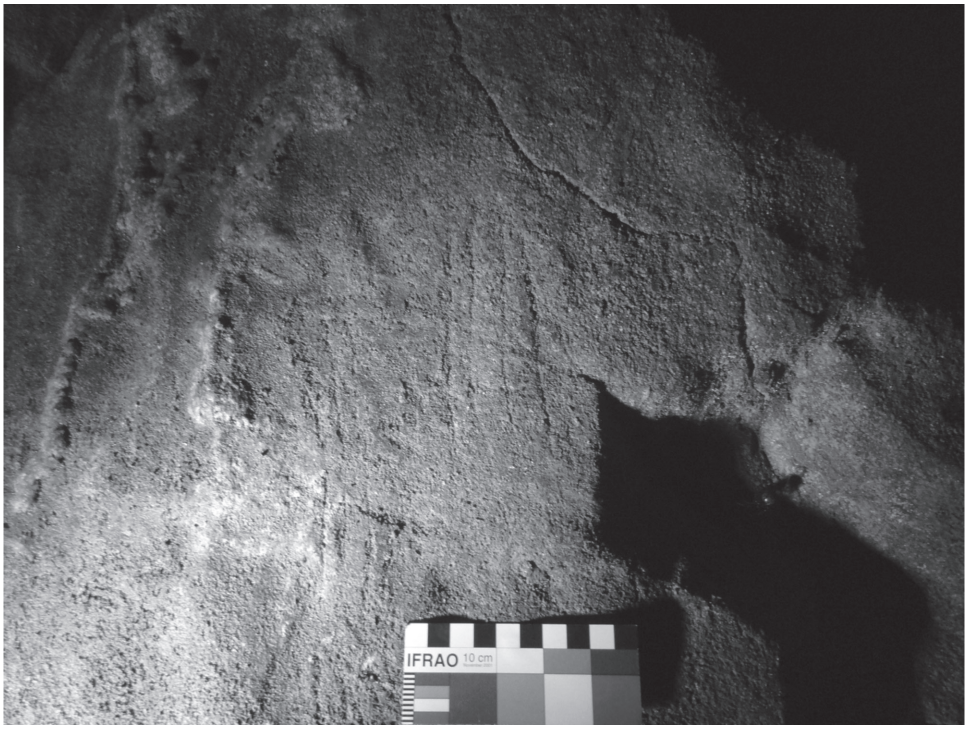

Figure 11.6. Scratches made by European brown bear, located in a side chamber off the main gallery.

to be too small for chronometric dating (*ibid*., 58).

Following a series of incidents in the recent past, the landowner, Forest Enterprise, and the Welsh heritage agency CADW decided in early 2012 to construct a grille across the rear section of the cave, thus protecting the fragile archaeology, the rock art, and the wildlife that currently inhabits it. Prior to constructing the grille, Scheduled Monument Consent (SMC) was required from the Welsh heritage agency CADW as Cathole is designated a Scheduled Monument (SM No. GM 349). As part of the construction methodology for the grille, a linear trench was archaeologically excavated in order to secure the lower section of the grille to the underlying bedrock. The excavation, undertaken by Elizabeth Walker (National Museum of Wales) revealed a shallow stratigraphy of mainly rock-fall and cave earths. Within this stratigraphy were a number of finds that included lithics and faunal remains, possibly representing material that was overlooked from the Colonel Wood excavation.

Discovery and description of the engraved cervid

Against this busy archaeological backdrop, the author and several members of the Clifton Antiquarian Club, Bristol – Christopher Castle and Stephen Tofts – began to explore Cathole Cave in 2007, specifically to look for rock art. The impetus for this was firmly based on the discoveries within several caves on the Mendip Hills, Somerset (Mullan and Wilson 2005). The first visit resulted in the discovery of several European brown bear (*Ursus arctos*) claw marks that were probably made following a hibernation event, and a possible engraved geometric pattern within an antechamber located north of the main gallery (Figure 11.6). Despite optimism within the team, the general consensus was that the irregular patterning would be difficult to authenticate. This was further supported by several of the scientific analysts who visited the cave in April 2011 and considered the panel to be natural.

During a visit to the cave on September 18th 2010, further exploration resulted in the discovery of an engraved cervid, probably a reindeer, on a vertical panel inside a discrete niche northeast of the main gallery, approximately 10.5 m from the cave entrance. This almost hidden engraving is the first clear evidence of Pleistocene rock art in Wales and only the second discovery of this type and date made in Britain.

The probable reindeer, measuring approximately 15 x 11 cm, was carved using a pointed flint awl-like tool (Figure 11.7). The figure has a number of characteristics that resemble carved reindeers found elsewhere in northwest Europe. The elongated torso is infilled with vertical and diagonal lines incised into a stabilised speleotherm, which completely covers a smooth water-

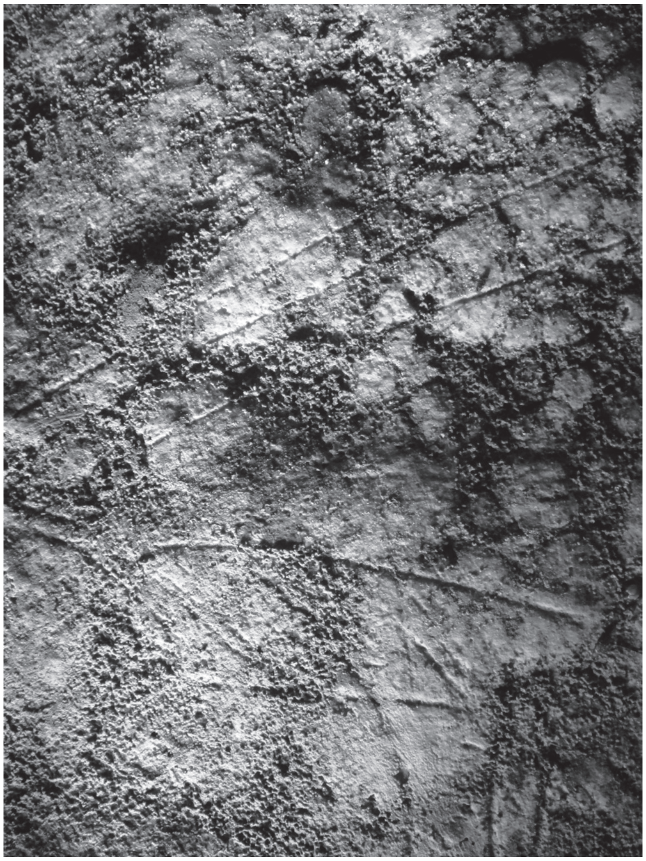

Figure 11.7. Image showing the torso, legs and antler set of the cervid.

worn limestone surface. Several internal diagonal lines extend below the lower section of the torso, merging to form three of the four legs, the longest measuring 4.5 cm. Incorporated into the left side of the torso and continuing beyond the head (or muzzle) of the reindeer is a thin rectangular block (the pedicle) on which three lines extend forming the beam and peal of a stylised antler set.

The figure is inscribed into a surface of botryoidal calcite flowstone, similar in general character to that found widely through the cave (Nash *et al*. 2012). This flowstone has a rather opaque, white, almost chalky appearance and little evidence for significant recent deposition. Individual flowstone bosses, or botryoids, are ~10–20mm across and of low relief (<5mm) (Simms 2011). Most of the inscribed lines fall into one of three distinct groupings of straight and sub-parallel lines, with each group at a significant angle to others. All of the lines commence and terminate within the area of flowstone, cut across the botryoidal-textured surface with no apparent effect from it, and do not extend onto the limestone surface beyond it. The straightness of the lines and their confinement within the area of flowstone is particularly strong evidence for a non-natural origin. Any natural fractures, or etched lines, are likely to have been influenced by the curvilinear botryoidal texture of the flowstone to at least some degree, but this does not appear to be the case with any of the lines that together form this figure. Secondly, all of the lines are very shallow and of fairly constant depth and width. Again, this is contrary to what might be expected for natural fractures or etched lines, as exemplified by the numerous small-scale fractures visible on limestone surfaces elsewhere in the cave. From field observations it was impossible to estimate the age of these inscribed lines except in the very broadest terms, but a few pertinent observations can be made. Firstly, the lines are no longer as sharp as if they had just been inscribed, but are encrusted with very fine crystals of calcite that must have been deposited by a very fine water film since the scratches were made. This same finely crystalline texture is also found across the unaltered surface of the flowstone into which the inscription has been made. The left-hand extremity (interpreted as the 'nose') has been partly covered by a fairly narrow, vertical strip of flowstone that is subtly different from the flowstone beneath. It has a smoother surface, lacking the fine crystals of the botryoidal flowstone, and has a faint greyish tone at the surface and a chocolate-brown layer beneath. This flowstone strip was slightly damp when observed and appears related to a drip point on the alcove roof immediately above, suggesting it may still be active. The two distinct layers suggest a significant change in percolation water chemistry during its growth, which could reflect a change in the extrinsic environment (if early- or pre-Holocene) or land use (if mid-Holocene or later).

Following the discovery, the authors undertook the task of recording the reindeer. Due to the fragility of the engraving and the surface on which it was engraved, no direct contact tracing was made. Furthermore, the confined space of the niche prevented conventional cameras from being used and instead a series of overlapping images were thus stitched and a tracing made (Figure 11.8).

Its concealed location within a tight niche in the inner section of the cave is, again, not uncommon in terms of Western European Pleistocene rock art; its discreteness suggesting a personalised shrine. The predominance of the Creswellian lithic assemblage initially suggested the reindeer may be contemporary, thus dating to between 12,000 and 15,000 cal. BP.

Dating the engraving

Following the initial discovery and verification process, members of the NERC-Open University Uranium Series Facility extracted samples from the surface on which the engraving was made in April 2011, together with

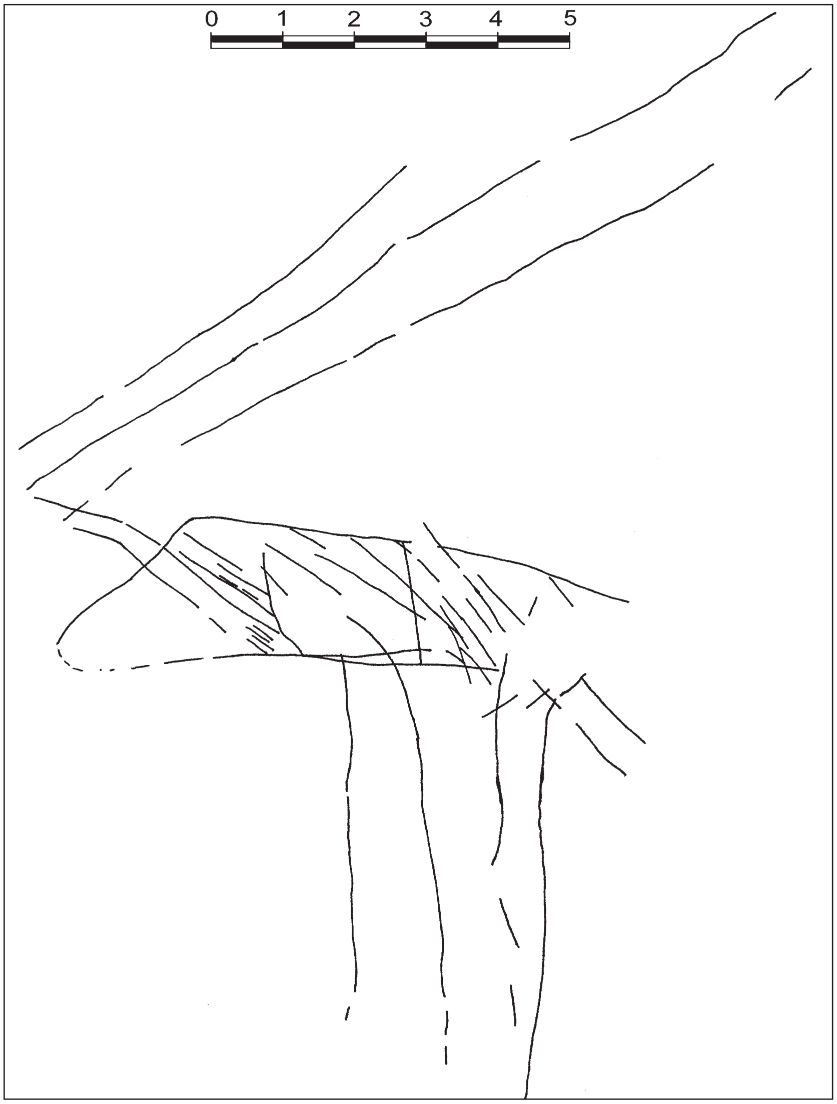

Figure 11.8. Tracing of the stylised reindeer, from stitched digital imagery (traced by George Nash).

a sample from a section of flowstone covering part of the reindeer's muzzle. A single date of 12,572 ± 600 years BP was obtained from the overlying flowstone, suggesting a minimum age for the engraving (Nash *et al*. 2010, 2012). A further flowstone sample was taken from left of the muzzle in July 2011 and results give a similar minimum age of 14,505 ± 879 years. This sample provides corroborative evidence of the age and confirms the absolute youngest age for initial flowstone development. Two other samples exhibited open system behaviour with some clay contamination, and did not yield ages.

The 12,572 ± 600 BP date arguably coincides with a period of climatic amelioration in the British Isles, falling between the warm conditions of the Windermere Interstadial and the 1,000 year cold snap of the Loch Lomond Stadial, commencing around 11,000 BP. At its maximum, and based on coleopteran remains, average annual temperature during this cold phase was between minus 10 and 12 degrees centigrade. At this time, human settlement activity appears to have extended only as far north as the Loire Valley in central-western France; artefact evidence elsewhere is limited. Following the abrupt onset of climatic amelioration around 13,000 BP, groups of hunter/fisher/gatherers began to utilise this somewhat hostile landscape, seasonally occupying many of the caves that formed within the frequent limestone outcrops along the Gower Peninsula. In re-evaluating Gough's Cave in Cheddar Gouge, Jacobi and Higham (2009, 1903) have collated a series of chronometric dates that chart the initial occupation of the site through to its abandonment; it is probable, based on similar diagnostic flint tools and faunal remains that human activity at Gough's Cave and Cathole are roughly synchronous.

Allen and Rutter (1948), Rutter (1949) and, later, Green and Walker (1991) recognise at least 31 caves on the Gower that potentially have a Palaeolithic presence, many of which contributing to an extensive Pleistocene faunal assemblage. Garrod (1926), Campbell (1977) and Stuart (1982) have identified the presence of arctic fox, brown bear, elk, horse, mammoth, red deer, red fox, wild cattle, and wolf in South Wales during the Windermere Interstadial. Despite the disappearance of mammoth at around 12,000 years ago (probably as a result of mass extinction, or due to so-called overkill), reindeer, a species sensitive to climatic conditions, disappeared during the Windermere Interstadial, but returned around 11,000 cal. BP, prior to and during the onset of the Loch Lomond Stadial, which established a more favourable climate dominated by colder, dryer conditions (Stuart 1982). By around 10,000 BP this tundra-loving species appears to have migrated northwards, beyond the current shoreline of the British Isles, seeking cooler climes. The stylistic characteristics, such as muzzle shape, antler set and infilling of the torso, are not uncommon, with pecked reindeer engravings found along the fjords of central, southern and western Norway. However, I would stress that I am not making any direct association between the Gower discovery and Norwegian hunter/fisher/gatherer rock art. Its location, hidden within a tight niche in the inner section of the cave, is again not uncommon in terms of the Pleistocene rock art of southwest Europe, its discreteness suggesting a sacred place and a personalised shrine.

Conclusion and contextual considerations

It is indeed a rare occurrence for Pleistocene rock art to be discovered within the British Isles. Prior to the 2010 discovery in South Wales, only two other discoveries had been made, at Church Hole and Robin Hood Caves, Creswell Crags, on the Derbyshire/Nottinghamshire border in April 2003 (Bahn and Pettitt 2009) and a possible mammoth engraving at Gough's Cave in Cheddar Gorge, Somerset (Mullan *et al*. 2006). The Creswell figures are considered to be Europe's most northerly Palaeolithic rock art. This discovery included a small number of anthropomorphic and zoomorphic engravings and bas-relief figures, including a bison, red deer and several avian species. Several of these engravings were stratigraphically overlain by a thin veneer of calcium carbonate flowstone and were ascribed a minimum age of 12,800 BP using the Uranium Series disequilibrium dating method (Pike *et al*. 2005). Several of these figures, including the red deer, used the natural topography of the cave wall to construct or enhance various parts of the animal; a common theme running throughout European Upper Palaeolithic and Mesolithic rock art.

Associated with the Creswell discovery, and recovered from other nearby caves within the gorge, were a number of Upper Palaeolithic mobile artefacts discovered during the course of late nineteenth and early twentieth century excavations (see Bahn and Pettitt 2009). These included Creswell's infamous horse, that had been carved on a piece of rib-bone and discovered in 1876, and a bird-like head on a human torso which had been carved on a piece of bone from a woolly rhinoceros (*Coelodonta antiquitatis*), a species considered to have become extinct in Britain by around 15,000 BC. The presence of these exotic artefacts, along with a handful of other portable 'valuables' from other Upper Palaeolithic core areas of Britain, including perforated shell and stone made for garment decoration, necklaces and pendants, is set against a backdrop of sometimes rapid climatic amelioration.

Prior to the Creswell discoveries, there had been several false dawns, where Upper Palaeolithic rock art had been discovered and authenticated but later rejected. One of these so-called discoveries occurred at Bacon Hole on the Gower Coast in 1912, when experts of the day – the French verifier, Abbé Henri Breuil, and W. J. Sollas – reported in *The Times* (14th October) the discovery of ten parallel red streaks of haematite within one of the recesses of the cave. *The Times* reported it as 'the first example in Great Britain of prehistoric cave painting'. However, this discovery turned out to be either natural haematite secretions or paint, possibly from a sailor merely cleaning his brushes (Bahn *et al*. 2003)!

A second discovery, in the Wye Valley of South Herefordshire in 1982, was claimed as Britain's first representative Palaeolithic rock art and included the outline of a bison and a red deer, amongst other animals, from Cave 5615, located high above Symond's Yat. The discovery was duly reported in the popular press and later the academic world but lacked any expert validation and, following a series of personal attacks, rebuttals and a confession or two, the discovery was soon rejected (Sieveking 1982; Sieveking and Sieveking 1981).

Placing the engraving into a wider context

Based on previous investigations in and around the site over the last 150 years, the cave can be considered one of Wales' most important Upper Palaeolithic sites, with a potential archaeological sequence extending, albeit intermittently, over a period of some 25,000 years. The predominantly lithic and faunal assemblages from the Wood, McBurney, and Campbell excavations offer clear evidence of human activity extending from the

Late Upper Palaeolithic into the succeeding Mesolithic and later prehistoric periods (Campbell 1977; Garrod 1926; McBurney 1959). How then does the engraved cervid fit into the overall sequence and are there any assumptions to be made concerning the landscape in which it lived and that of the artist?

The disappearance and subsequent return of the reindeer within the palaeoenvironmental record creates an interesting discussion point, in that the stal covering the engraving has been dated to 12,572 ± 600 years BP (CH-10 GHS2) and 14,505 ± 879 years BP (CAT 11 #4). If it is accepted that reindeer inhabited the tundra landscape at around 13,000 BP and before, and again during the Loch Lomond Stadial (between 10,000 and 11,000 BP), can one also suggest a presence here during the Windermere warming phase, or is it simply a case of mistaken identity and the Gower engraving actually represents another cervid, perhaps a red deer or elk? Certain attributes, such as the shape of the muzzle, the pedicle and brow tine (lower section of the antler set), and the shape of the torso, strongly suggest a reindeer, although it could be argued that similar attributes characterise carvings of elk, another cold-environment animal. If the confirmed date of the stal is accepted and the assumption made that whatever underlies it is earlier, the identification of the engraving as a reindeer is almost certainly correct. Clearly, the same could have been said if the stal had returned a date prior to the onset of the Loch Lomond Interstadial.

The pioneering work of D. Q. Bowen (1980) and Roger Jacobi (1980) spreads considerable light on the environment of South Wales and the Bristol Channel at this time. Bowen, reporting on the pollen sequence from the Campbell excavation in 1968, reveals systematic environmental and climatic changes that are clearly synchronous with the chronostratigraphy of Pollen Zones I, II and III. Pollen Zone I, denoting the appearance of thermophilous trees, appears to coincide with Creswellian artefacts recovered from Campbell's excavation. Pollen Zone II sees a rise in Betula, suggesting the climate is undergoing a gradual amelioration. A range of tundra flora characterises Campbell's Pollen Zone III, which thus represents the onset of the Loch Lomond Interstadial.

Despite the complexity of this small segment in early prehistoric time, it is probable that the engraving originates from a period when park tundra occupied the proglacial landscape (*i.e.* before 13,000 BP). The question is how far back before this date (or the dated stal)? As stated earlier, the dating of the stal that overlies part of the cervid provides a stratified minimum date. We know from the artefact record that several Font Robert points were recovered from the Wood excavation. The presence of such artefacts suggests that between *c*. 22,000 and 28,000 BP hunting communities were at the extreme edge of their geographic range and were using this and other caves within the area. Could the engraving belong to this period? Although I am rather sceptical of this possibility, one cannot dismiss the recent changes in chronometric dating to the so-called Red Lady of Paviland, a male burial that was excavated by the celebrated geologist William Buckland in 1823 at Goat Hole Cave. Since Kenneth Oakley's initial date of 18,460 ± 340 BP on this skeleton made during the 1960s, a reassessment in 1989 and 1995 has pushed the date of the burial further back to 26,350 ± 550 BP (OxA-1815) (Aldhouse-Green 2000; Aldhouse-Green and Pettitt 1998). In 2007 and 2009 further chronometric dating on the remains has confirmed a date of around 29,000 BP and 33,000 BP respectively (Jacobi and Higham 2008). This is at a time when the cave and much of the current Gower coastline was 120 km inland and sea-level around the British coastline was around 35–50 m lower than present. One must consider that the three postulated dates represent three very different landscapes and palaeoclimatic regimes. Moreover, and in hindsight, one cannot truly rely on dating alone especially as there is a significant deviation of at least 16,000 years between the first and final dates on the Paviland burial.

Either way, the reindeer with its minimum date probably signifies a landscape and climate that is alien to what we witness currently. Although one cannot tie down a *terminus post quem* date for this engraving, the dated stal covering part of it does place this animal in terms of environment to a period in time that was very cold and an open permafrost landscape that was probably devoid of trees. Despite the harness of this landscape, one member of a mobile hunter-gatherer community was inspired to make his or her discrete mark onto the back wall of a cave in South Wales, some 12 to 13,000 years ago.

Acknowledgements

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12. Ideology of the Hunt and the End of the Epi-Palaeolithic

Piotr Jacobsson

Introduction

Projectile points define the chipped stone industry of the south-west Asian pre-Pottery Neolithic (PPN; see Table 12.1 for chronology). The tradition originates with the el-Khiam points in the PPNA and develops towards larger forms in the PPNB, which would require blanks from specialised 'naviform' cores (Gopher 1994; Kozlowski 2001; Quintero and Wilkie 1995, 25). Their importance is also implied by discoveries in the obsidian sources at Kaltepe, Turkey, where the assemblage exhibits few knapping errors and disproportionately large numbers of cores, suggesting not only craft specialisation, but also production for exchange throughout the Levant (Binder and Balkan-Atli 2001, 9). Given the effort put into their creation, as well as disproportionately large sizes, the projectile points of the PPN appear to have a symbolic value beyond their utilitarian application (Peltenburg 2004, 3). Arrowheads form part of a broader phenomenon of association with hunting and broadly conceived 'wild things' that runs throughout the PPN. Perhaps the best known are the reliefs of wild animals at Gobekli Tepe, which, in the excavators' interpretation, are a part of an "ideology of the wild" (Schmidt 2010). This ideology is traced through the complex of art and artefacts focused on animals and plants that evaded domestication. Can a complex of art and artefacts be described as an ideology? According to White (1959) and Latour (2005), the answer is yes. A set of ideas is always linked into a network of references (White's locus of culture) and these referents can be material. In this sense art and artefacts are ideology. The importance of the relationship between material culture and the ideological process in the Neolithic is further substantiated by the fact that for the first millennium of the PPN, it is the materiality and not domestication that determines the period (Watkins 2010; Willcox *et al*. 2008). A question thus presents itself: how come projectile points were such an important part of this materiality?

The PPN arrowhead is an artefact whose form exceeds the requirements of functionality. However, in many places, such as 'Ain Ghazal, Jordan, they were often found in a broken state that, in the absence of unanimous evidence of endemic violence, implies use in hunting (Rollefson 2004, 2010) and hints that their symbolism was still connected to the function of killing animals. We also know that they took hold first in areas where gazelle were frequently hunted (see below). Therefore, some of the answer may lie in how the relationship between people and gazelle changed at the eve of the Neolithic.

This chapter explores what we need to know to evaluate this belief. Despite ambiguities within the Epi-Palaeolithic record some trends stand out. The Near East as a whole was showing signs of widespread networks early on. Gazelle were found in assemblages throughout these networks, despite the differing geographic contexts. This is interesting, as there are significant differences between gazelle species associated with different areas. Another point of interest is that the projectile point technology emerges in the Sinai and the Negev deserts at the end of the Epi-Palaeolithic, but the dispersal happened only with the onset of the Neolithic. The chapter concludes with an outline of how geographical variability and understanding of time are essential to our understanding of the relationships between humans, gazelle, and lithic technology.

Background: the Epi-Palaeolithic in the Near East

Seventy-five years have passed since Dorothy Garrod's discoveries of Epi-Palaeolithic remains at Shukba

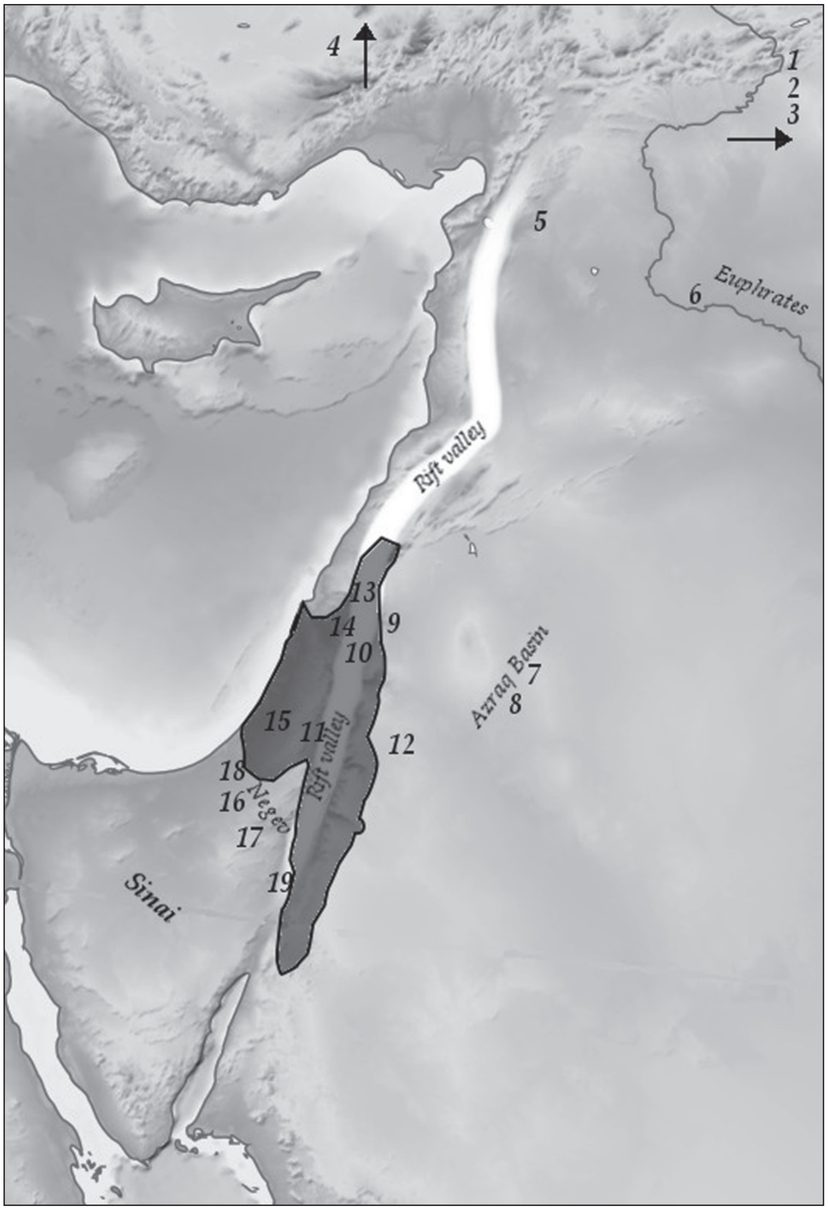

Figure 12.1. Area of study. The 'Natufian homeland' according to Bar-Yosef (1998) is shaded. Sites mentioned in text: 1. Gobekli Tepe; 2. Hallan Cemi; 3. Kortik Tepe; 4. Gollu Dag; 5. Tell Qaramel; 6. Abu Hureyra; 7. Kharaneh IV; 8. Wadi Jilat 6; 9. Wadi Ziqlab; 10. Ohalo II; 11. Jericho; 12. Tor al-Tareeq; 13. Ain Mallaha; 14. Nahal Ein Gev; 15. Hatoula; 16. Abu Salem; 17. Ramat Harif; 18. Shunera X; 19. Wadi Feynan 16 (WF-16).

Archaeological entity	**Approximate onset (kyr BP)**	**Approximate termination (kyr BP)**
Kebaran (Early Epi-Palaeolithic)	21.05	16.05–15.55
Geometric Kebaran (Middle Epi-Palaeolithic)	16.05–15.55	13.42–12.62
Natufian (Late Epi-Palaeolithic)	13.42–12.62	10.15–9.65
Pre-Pottery Neolithic A	10.15–9.65	8.7–8.6
Pre-Pottery Neolithic B	8.7–8.6	7.58–7.5

Table 12.1. Chronological outline of the discussed cultural and temporal entities. Dates from Maher et al. *(2011, tables 1 and 4). All dates in kyr cal. BC at 95.6% confidence intervals.*

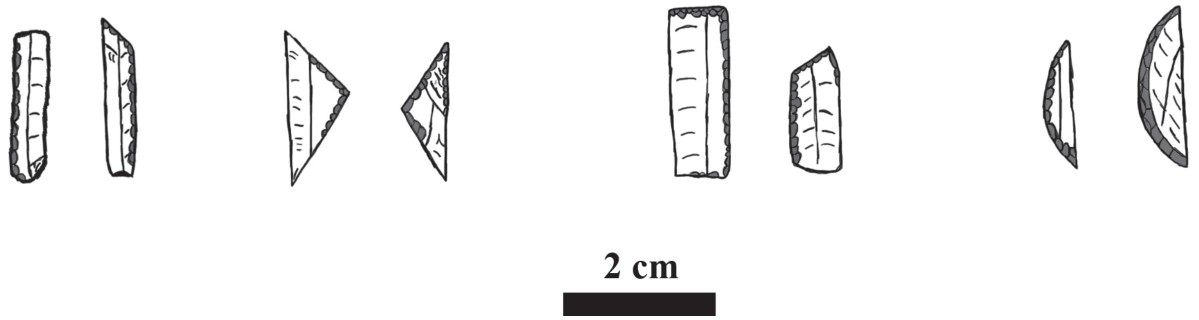

Figure 12.2. Fossiles directeurs for the Epi-Palaeolithic (left to right): bladelettes (Kebaran), triangles, trapezes (Geometric Kebran), lunates (Natufian). Illustration by P. Jacobsson, based upon Pirie (2004, figure 3) and Saxon et al. *(1978, figure 2).*

Cave in Wadi an-Natuf (Garrod 1932), but the details of what happened in the Epi-Palaeolithic remain elusive. This is primarily due to its length and scale: ten millennia in an area approaching 400,000 square kilometres (Figure 12.1). This means that the few dozen excavations and surveys conducted to date give us only snippets of information, which may well have missed major historical turns. Nevertheless, there is sufficient evidence to sketch a qualitative baseline of the main trends during the period, at least as far as chronology, lithic assemblages, settlement and mobility patterns, and subsistence are concerned. A list of the sites discussed is provided in Table 12.2.

The relative chronology of the Epi-Palaeolithic is based on a fossil directeur typo-chronology. This can be divided into three main units: the Kebaran, the Geometric Kebaran, and the Natufian. The Kebaran is defined by the high frequency of bladelets (Figure 12.2a), the Geometric Kebaran on the high incidence of geometric microliths (trapezes and triangles – Figure 12.2b–c), while the Natufian is characterised by lunates (Figure 12.2d; Bar-Yosef and Belfer-Cohen 1989). This typological focus is the function of reliance on survey data and poor preservation of organic materials, which makes the acquisition of large series of radiocarbon measurements difficult. Although absolute dates for the cultural phases are encountered in the literature, a recent review of the evidence by Maher *et al*. (2011) presents a picture of uncertainty, with the transition boundaries precise to about 500 years. This means that the rapidity of the transformations and their correlation with the climatic changes traceable through palaeo-environmental proxies cannot be evaluated given the currently available data. Furthermore, the sub-division of the main units is still in question, as shown by the recent revision of the Natufian sequence. Originally it was divided into the chronologically distinct early and late Natufian, based on changing sizes and retouch of the lunates. However, an on-going programme of re-dating sites using Bayesian modelling, based upon new series of AMS measurements, suggests that the two entities were contemporaneous on sites within the Mt.Caramel region (Barzilai *et al*. 2013). Thus division of the Epi-Palaeolithic cannot be specified with confidence beyond early, middle and late, which in the Southern Levant corresponds to the Kebaran, Geometric Kebaran and the Natufian.

The chipped stone that underpins the chronology of the Epi-Palaeolithic is also the backbone of the artefact assemblage. Although the general scheme has been shown not to be applicable throughout the Levant (*e.g.* Maher *et al*. 2001 on the lithic assemblage from Wadi Ziqlab), some general propositions appear robust in the face of continuing research (although see Pirie 2004 for a theoretical critique). Microlithic technologies involving relatively simple reduction sequences dominate the assemblages (Belfer-Cohen and Goring-Morris 2002). The versatility of the technology is demonstrated by the possibility of obtaining similar tool types from different production sequences (Richter 2007). Use-wear analyses are still few and have focus mainly on the later Epi-Palaeolithic assemblages, where a variety of functions have been proposed for the lunates (Richter 2007), including use as hunting armatures (Yaroshevich *et al*. 2010), as has been proposed for the microliths of the earlier Epi-Palaeolithic (Yaroshevich *et al*. 2013). Therefore, it is reasonable to assume that one of the functions of microliths was to act as elements of composite projectile points throughout the period. Unfortunately, the use-wear analyses have been confined so far to the areas west of the Jordan River.

Epi-Palaeolithic settlement was traditionally conceived as a progression towards increasing sedentism (Bar-Yosef and Belfer-Cohen 1989). However, discoveries in the early 1990s undermined this picture. Excavations at Ohalo II have shown the presence of huts and at least bi-seasonal activity in the early Epi-Palaeolithic (Kislev *et al*. 1992). More recently, evidence of huts has also been encountered in the early Epi-Palaeolithic Azraq basin at Kharaneh IV (Maher *et al*. 2012a). Therefore, the

Period	Site	Size (m^2)	Gazelle (%NISP)	Location	Reference
Early Epi-Paleolithic	KPS-75	100	n.d.	East	al-Nahar *et al.* 2009
	Jebel Hamra J201	320	n.d.	East	Pirie 2001
	Tor al-Tareeq	812	n.d.	East	Neeley *et al.* 1998
	Uwaynid 14	1200	54.6	East	Byrd 1988; Garrard *et al.* 1988
	Uwaynid 18	1200	69.7	East	Byrd 1988; Garrard *et al.* 1988
	Wadi Jilat 6 Early	19000	72.1	East	Garrard and Byrd 1992; Martin *et al.* 2010
	Kharaneh IV A-C	21000	86.1	East	Garrard and Byrd 1992; Garrard *et al.* 1988
	Ain Quisaya	n.d.	60.8	East	Richter *et al.* 2009
	Nahal Hadera V	209	72.33	West	Saxon *et al.* 1978; Bar-Oz and Dayan 2002
	Ein Gev I	2000	44	West	Belfer Cohen *et al.* 2004; Bar-Oz *et.al.* 1999
	Ohalo II	2000	74.9	West	Weiss *et al.* 2008; Humphrey 2012
	Ein Quedem	8000	n.d.	West	Rosenberg *et al.* 2011
	Nahal Oren	cave	77	West	Bar-Oz *et al.* 1999
	Hayonim C	cave	82	West	Bar-Oz *et al.* 1999
	Meged	n.d.	40.2	West	Humphrey 2012
	Fazael IIIa	n.d.	73	West	Bar-Oz *et al.* 1999
	Urkan E Rub IIa	n.d.	95.11	West	Humphrey 2012
Middle Epi-Palaeolithic	Tabaqat al-Buma	150	n.d.	East	Maher *et al.* 2001
	Tor Hamar J431	300	n.d.	East	Pirie 2001
	Uyun al-Hammam	1500	16.91	East	Diaz *et al.* 2012; Maher *et al.* 2001
	Kharaneh IV D	21000	90.6	East	Garrard and Byrd 1992; Garrard *et al.* 1988
	Yutil al-Hasa	Rock shelter	60	East	Olszewski *et al.* 1994
	Nahal Lavan VI	15	n.d.	South	Phillips and Bar-Yosef 1974
	Shunera 12	20	n.d.	South	Pirie 2001
	Shunera 12b	20	n.d.	South	Pirie 2001
	Shunera 8	25	n.d.	South	Pirie 2001
	Nahal Lavan II	40	n.d.	South	Phillips and Bar-Yosef 1974
	Nahal Rut 48D	60	n.d.	South	Gilead and Marder 1989
	Nahal Rut 48C	63	n.d.	South	Gilead and Marder 1989
	Shunera 21	80	n.d.	South	Pirie 2001
	Shunera 4	80	n.d.	South	Pirie 2001
	Nahal Rut 48B	90	n.d.	South	Gilead and Marder 1989
	Nahal Rut 48A	100	n.d.	South	Gilead and Marder 1989
	Ma'aleh Ziq	150	n.d.	South	Goring-Morris 1978
	Neve David	1000	60	West	Bar-Oz *et al.* 1999
	Hefizbah 1-6	n.d.	67	West	Humphrey 2012
	Hefizbah 1-6	n.d.	73	West	Humphrey 2012

Table 12.2. Sites mentioned in the text and referred to in the figures (continued overleaf).

diachronic 'progression to sedentism' model may stem from the research bias toward the late Epi-Palaeolithic (Richter *et al*. 2011, 96). Incidentally, variations of this model may also overlook some of the geographical variability throughout the region.

From the perspective of Epi-Palaelithic and Neolithic archaeologies of the area, the Jordan valley constitutes the main geographic division. The valley is flanked by hills on both sides, which extend to the Mediterranean in the west and in the east give way to more subdued terrain and deserts. In the southern Levant the areas west of the Jordan correspond to the 'Natufian homeland', or what is the distribution of the Early Natufian lithic industries (Bar-Yosef 1998). Finally there are the areas to the south of the Dead Sea: the Sinai and Negev deserts. The three-fold division corresponds with changes in site sizes (Figure 12.3). Sites as large as 6000 m^2 are present on both sides of the Jordan River; however, aggregation sites of more than 10,000 m^2 have been identified only to the east (Kharaneh IV and Wadi Jilat 6). Meanwhile,

Period	Site	Size (m^2)	Gazelle (%NISP)	Location	Reference
Late Epi-Palaeolithic	Wadi Rajil 14/7	10	n.d.	East	Betts 1982
	Wadi Hammeh 27	340	65.2	East	Edwards 1991
	Wadi Jubaid J2	400	21.51	East	Henry et.al. 1985
	Iraq ed Dubb	450	45.6	East	Kuijt *et al.* 1991; Edwards and Martin 2007
	Site J614	500	n.d.	East	Henry *et.al*. 2001
	Jeftelik	1000	n.d.	East	Haidar-Boustani *et.al*. 2007
	Khallat 'Anaza	2000	24.14	East	Betts 1991
	Azraq 18	2200	23.6	East	Garrard and Byrd 1992; Garrard *et al.* 1988
	Azraq 17 late	2200	94.9	East	Garrard and Byrd 1992; Garrard *et al.* 1988
	Wadi Jilat 22	5500	n.d.	East	Garrard and Byrd 1992
	Wadi jilat 8	6300	79.4	East	Garrard and Byrd 1992
	Wadi Jilat 6 Late	19000	73.2	East	Garrard and Byrd 1992; Garrard *et al.* 1988
	Mureybet	n.d.	48.84	East	Helmer 1991
	Abu Hureyra	n.d.	80	East	Legge and Rowley-Conwy 2000
	'Small Harifian site'	42	n.d.	South	Phillips and Bar-Yosef 1974
	Abu Salem	500	n.d.	South	Goring Morris 1987
	Nahal Lavan IV	20	n.d.	South	Phillips and Bar-Yosef 1974
	Nahal Sekher VI	60	n.d.	South	Goring-Morris and Bar Yosef 1987
	Moshabi IV	200	n.d.	South	Phillips and Bar-Yosef 1974
	Ramat Harif	500	n.d.	South	Goring Morris 1987
	Rosh Zin	900	16	South	Marks 1971; Horwitz and Gorring-Morris 2000
	Upper Besor 6	1000	65	South	Horwitz and Goring-Morris 2000
	El Wad terrace	600	89.7	West	Henry *et al.* 1981; Bar-Oz *et al.* 1999
	Salibiya I	1200	89.4	West	Crabtree *et al.* 1991; Bar-Oz *et al.* 1999
	Hatoula	2000	80	West	Ronen and Lechevallier 1991; Davis 1989
	Hilazon Tachtit	Cave	26	West	Humphrey 2012
	El Wad cave	Cave	57	West	Humphrey 2012
	Hayonim B	Cave	58.4	West	Bar-Oz *et al.* 1999
	Nahal Oren	Cave	83.3	West	Bar-Oz *et al.* 1999
	Ain Mallaha	n.d.	65	West	Humphrey 2012
	Fazael VI	n.d.	76	West	Humphrey 2012
	Hayonim terrace	n.d.	83	West	Bar-Oz *et.a*l. 1999

Table 12.2. continued.

in the Sinai and Negev, the data available indicate diminution by an order of magnitude. It needs to be borne in mind, however, that the intensive surveys of the Sinai and the Negev in the 1970's and 1980's resulted in a collection of a vast amount of data from an area undisturbed by modern farming (Goring-Morris 1987). So the frequency of the small sites on distribution maps may be the function of site survival and survey intensity. Nevertheless, present information suggests the following pattern: the areas east and west of Jordan are generally similar in terms of site size; however the east also sees the presence of large sites, while settlements in the Sinai and Negev tend to be much smaller. With only a limited number of sites fitting the picture of 'sedentisation' in the late Epi-Palaeolithic, the diachronic trend needs verification (Olszewski 2004), which led Finlayson *et al*. (2011a) to consider the architectural remains, such as the 'cult structure' at Ain Mallaha, as evidence of growing reliance on material culture and not greater sedentism.

Questions of settlement are linked to questions of mobility and exchange. Annual movement of Epi-Palaeolithic people has been modelled by circular and radiating residential mobilities. Circular residential mobility refers to an itinerary of a nomadic cycle, moving from location to location throughout the year. Radiating residential mobility is based on the idea of a semi-permanent base-camp, from which expeditions

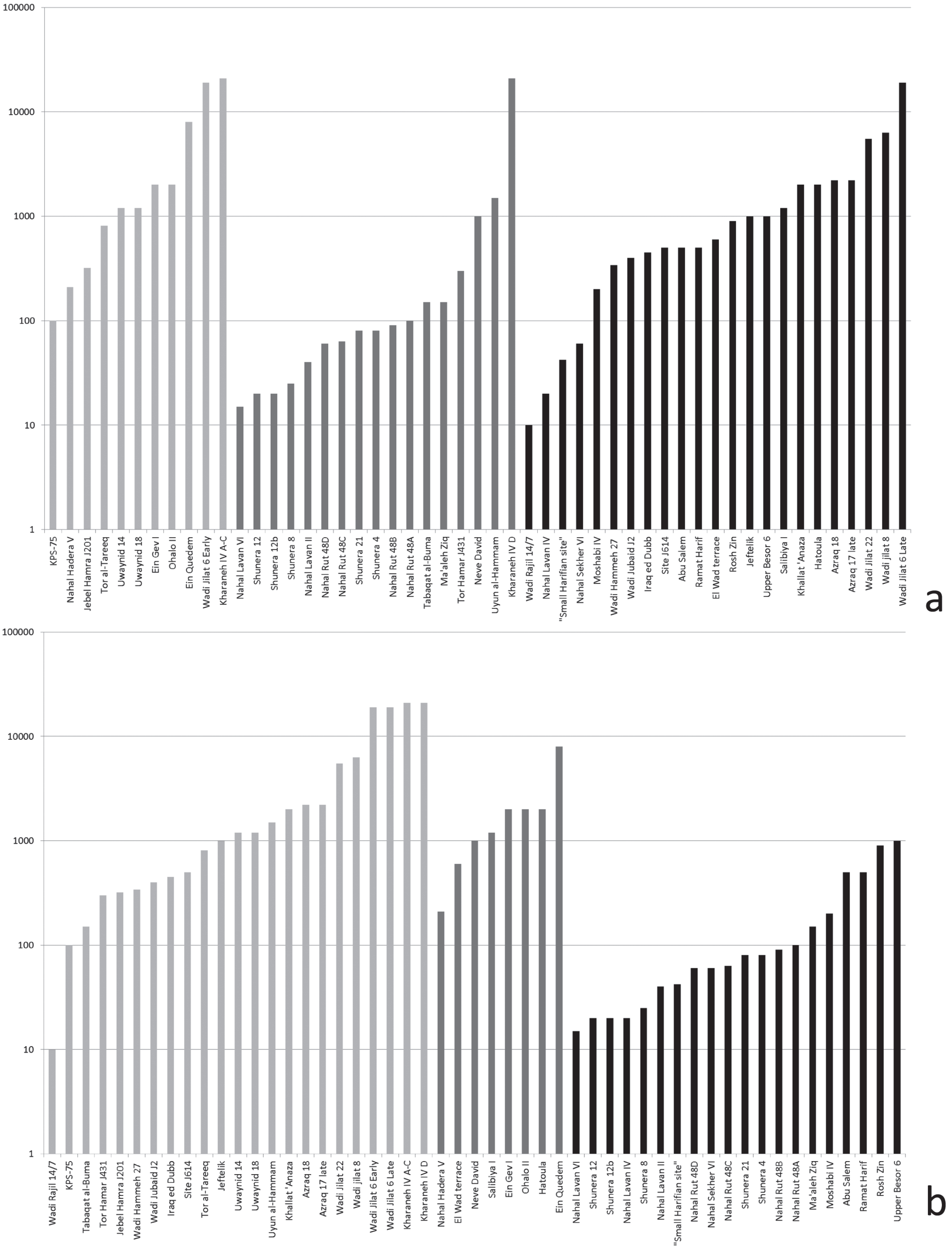

Figure 12.3. Site sizes: a. by period (light grey = Early; grey = Middle; Black = Late); b. by region (light grey = east of the Rift Valley; grey = Rift Valley and the west; black = Sinai and Negev Deserts).

would take place (Neeley *et al*. 1998). When applied, this model breaks down in the face of material complexity, as at Tor al-Tareeq (Neeley *et al*. 1998), or in the face of the chronological developments proposed by Goring-Morris (1987) for the Negev and the Sinai. Given that this model does not hold in the context of hunter-gatherer studies generally (Kelly 1992), keeping it as a baseline reference for the ten millennia of the Near Eastern Epi-Palaeolithic is unjustified.

A consideration of the range of exchange networks throughout the period might be more informative. The sites in the southern deserts are of further interest, as a number of them, such as Shunera 4 or Nahal Seker IV, have produced both Red Sea and Mediterranean shells (Goring-Morris and Bar-Yosef 1987; Pirie 2001) Similar finds characterise the aggregation sites of the Azraq Oasis, where shells from the Indian Ocean have also been found (Richter *et al*. 2011, 105). The limited strontium analyses from late Epi-Palaeolithic burials indicate a blend of mobility strategies (Shewan 2004), although the paucity of such studies makes it impossible to draw firm conclusions. Nevertheless, recurrence of such findings shows that the supra-regional interaction network, which forms the subject of much Neolithic research in the Near East, may have already begun in the early Epi-Palaeolithic (Maher *et al*. 2012b).

The field of Epi-Palaeolithic subsistence studies may undergo a revision in the coming years. Until recently it was dominated by the notion of an increasing intensification throughout the period (Davis 2005; Munro 2009; Stutz *et al*. 2009). On the vegetal side, this hinges on the slow development towards plant cultivation, yet such syntheses are still based on very limited samples and differing definitions of what constitutes cultivation (Olszewski 2004, Willcox *et al*. 2008). Hence the intensification narrative is substantiated by the increasing diversity of faunal remains, especially microfauna, and its consistency with Flannery's 'broad spectrum revolution' (1969). Under this scenario the hunter-gatherer populations, driven by increasing demographic pressure would begin collecting more wild grasses and be forced to prey on a greater number of species, because the increased hunting would deplete the preferred big game species. Recent syntheses defend the broad spectrum revolution for the Mediterranean zone (Stutz *et al*. 2009) and there is evidence that this may be the case further afield (Munro 2009). Nevertheless, the hypothesis tying the increasing human population pressure from the end of the last glacial and the diversification of prey still rests on studies of a limited geographical span with poor chronological constraint. The most comprehensive study is that of Stutz *et al*. (2009), yet it consists of only eight assemblages, of which five belong to the later Epi-Palaeolithic and all are located west of the Jordan River. Through inclusion of sites from the Jordan Valley itself, Humphrey (2012) made an argument that the changing proportion of different species within the faunal assemblages was the function of changing residential practices, rather than an increase in human predatory pressure. Therefore, while we do know that there are changes in the proportions of NISP throughout the period, their interpretation may be ambiguous. Once again this reduces to the question of scale: given the area over which the Epi-Palaeolithic developed, it is unlikely that a single model of subsistence change will be applicable.

In spite of the ambiguities mentioned in the preceding paragraphs, some general observations on the Epi-Palaeolithic hold. The chronology defined by the Kebaran, Geometric Kebaran, and Natufian industries appears robust. The understanding of the lithic material is generally good and indicates a local variability, underpinned by the common theme of microlithisation. There is no unanimous indication of greater sedentism towards the end of the Epi-Palaeolithic and variability in the size of settlements is maintained throughout the region. However, there is a broad geographical difference in that only areas east of the Jordan have confirmed agglomeration sites of more than 10,000 m^2. Likewise the Sinai and Negev deserts host much smaller sites than regions elsewhere. There is displacement of seashells throughout the Epi-Palaeolithic, suggestive of migration, exchange networks, or a combination of the two. Finally, in some place, there is a move towards greater prey diversity with time.

There is also one other unambiguous factor: gazelle dominate faunal assemblages throughout the Epi-Palaeolithic and into the beginning of the Neolithic. When did this domination develop? The seminal study by Davis (1991, 2005) observed a steady decrease in game variability from the Mousterian at Biqat Qunetira to the gazelle-dominated Natufian assemblage of Nahal Ein Gev II. Davis interpreted this as the result of predatory pressure triggered by increasing human populations after the Last Glacial Maximum and into the Holocene. The final element of this hypothesis comes from the PPNA Hatoula, which present a growing proportion of juvenile animals. Given that hunters would preferentially choose adult animals, the increased proportion of juveniles was seen as an indicator of the further depletion of game stocks.

Against Davis' hypothesis, one can amass observations from throughout the territories of modern Syria, Israel, and Jordan. For example, at Abu Hureyra the high proportion of juvenile animals was interpreted in terms of hunting techniques, rather than increased pressure on the gazelle population (Legge and Rowley-Conwy 2000). Furthermore, high proportions of juveniles have also been encountered throughout the early and middle

Epi-Palaeolithic at Kharaneh IV and Wadi Jilat 6 (Martin *et al*. 2010). A more general overview shows no apparent trends in changing gazelle frequencies, neither in time, nor location in terms of the east/west division (Figure 12.4). This implies that there is no evidence for an increase in pressures on gazelle populations on a supra-regional scale in the Epi-Palaeolithic itself. This inverts the question: how come the practice is maintained in some form or another throughout such an expanse of time and space?

Gazelle and people

Hunting and meat consumption are a potential contributor to the maintenance of a human society. This is because of the nutritional properties of meat, as well as the situations created in the context of the hunt. Meat is rich in glutamate, which is a good source of amino acids, as well as a substrate for the production of the neurotransmitter glutamine (Smith and Wilmore 1990). Given its importance, our sense of taste has evolved sensitivity towards it (Yamaguchi and Ninomiya 2000). Furthermore, glutamate was shown to lead to mood improvements (Mosel and Kantrowitz 1952; Young *et al*. 1993). However, to take advantage of meat as a glutamate source, it needs to be caught first, which in primates is often a collective endeavour. Among chimpanzees, the most successful hunting troupes are those that organise their hunting as a pack, like the Tai (Boesch 2005). Indeed, it is the presence of a large number of chimpanzees, rather than a demand for food, that predicts whether the troupe will set out on a hunt (Watts and Mitani 2002). Thus, the hunts provide opportunities for the chimpanzee troupes to meet at large and redefine their hierarchies (Boesch 2002; Mitani and Watts 2001). Although drawing direct conclusions from primatology is a dubious exercise, the sensual attraction of meat is a general trait encountered in all humans, and hunting in groups is also advantageous to *Homo sapiens*. Once the group has gathered for the hunt, the meat needs to be redistributed and the whole process becomes a feature that aids the perpetuation of interaction within and between hunter gatherer-bands. However, it is not only the sociality of the hunter that determines the nature of the hunt, but also the sociality of the species hunted.

The Epi-Palaeolithic gazelle hunters could encounter one of two species of Near Eastern gazelle, depending on which side of the Jordan valley they were on. One was the Persian gazelle (*Gazella subgutturosa*) and the other a smaller mountain gazelle (*Gazella gazella*). The latter species occupies the hilly habitats within and to the west of the Jordan valley, whilst the former relies on the open areas to the east. Although in modern times a third species, *Gazella dorcas*, is also encountered, it most likely migrated from Africa with increasing desertification during the Holocene (Yom Tov and Ilani 1987).

Mountain gazelle (*Gazella gazella*), is the smaller species, weighing between 16.5 and 30 kg (Mendelssohn *et al*. 1995). It has good sight and can run up to 80 km/h in rugged terrain, although the animals prefer to keep to paths (*ibid*.). At the same time, they form much smaller groups (mean of 1.68 individuals, see Habibi *et al*. 1993). Mountain gazelle are stationary: in Saudi Arabia animals from re-introduced populations rarely moved beyond an area of 10 km^2 (Dunham 2000). As in the case of Persian gazelle the reproduction rates are high. Between 1948 and 1985 their population in Israel grew from 500 to about 10,000 individuals (Mendelssohn *et al*. 1995). Also, they will reproduce year-round, given favourable conditions, the most important of which is access to water during lactation (Baharav 1983). Furthermore, they can endure arid conditions by relying on plant water, although this results in defined birthing seasons (*ibid*.). From the perspective of an Epi-Palaeolithic hunter the mountain gazelle would be more difficult to hunt, as their pack sizes preclude efficiency of mass killings and speed and sight gives an advantage in the context of stalking single animals. On the other hand, their reproduction rates would make them a reliable hunting species.

The Persian gazelle is the larger of the two species, with body weight ranging between 18 and 43 kg (Kingswood and Blank 1996). It avoids cliffs, ravines, and wooded areas, which characterise the regions west of the Jordan River (*ibid*.). It is known to form herds, which in historical travellers' reports reached thousands (Legge and Rowley-Conwy 2000), although modern populations in Saudi Arabia and central Asia tend not to exceed groupings of *c*. a hundred (Cunningham and Wronski 2011; Qiao *et al*. 2011). Formation of large herds is not a frequent event (mean herd sizes oscillate around 6.5 individuals in central Asia, see Qiao *et al*. 2011) and their emergence appears to be controlled by rainfall (Cunningham and Wronski 2011) and breeding cycle (Blank *et al*. 2012). The breeding cycle is characterised by births occurring in March and April (Habibi *et al*. 1993). The reproduction rate is high; at Bukhara Breeding Centre (Uzbekistan) a population of 44 animals released in 1977 peaked in 1989 at 1224 individuals (Pereladova *et al* 1998). However, they are also vulnerable to habitat overloading and deterioration of climatic conditions. Following the 1989 peak the Bukhara herd declined to 580 by 1995 (*ibid*.). This sensitivity is likely linked to the migratory patterns of Persian gazelle. During lactation daily access to water is necessary and at the same time the species cannot sustain itself in areas covered by snow. Taken together, these two factors appear to have been the drivers

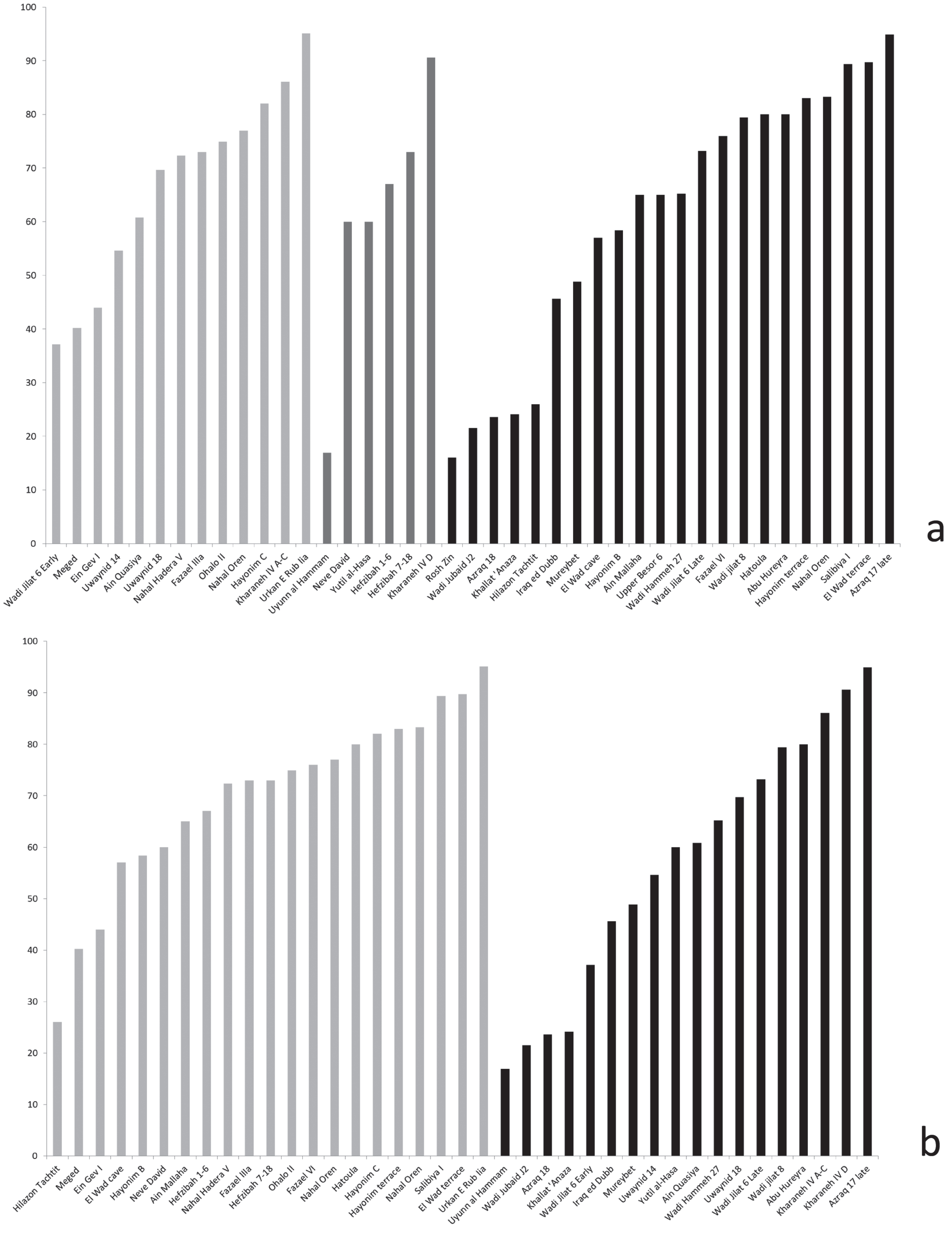

Figure 12.4 Gazelle frequencies as reported NISP percentages: a. by period (light grey = Early; grey = Middle; Black = Late); b. by region (light grey= Rift Valley and the west; black = east of the Rift Valley).

of the historical migrations (Martin 2000). From the perspective of an Epi-Palaeolithic hunter this means that, if the population of Persian gazelle in the region is large enough and if there are significant geographical variations in water and grazing availability, movement of large numbers of these animals on an annual basis can be expected.

The aggregation sites, as noted above, appear only to the east of the Jordan Valley, within the distribution zone of the Persian gazelle. The faunal assemblages of these sites are gazelle dominated and the age and sex distributions are close to those that would be expected in a living population (Martin *et al*. 2010). Similar results, coupled with the fact that the age groups were specifically new-borns and juveniles just under one year, were obtained at Abu Hureyra 1. This has been interpreted as evidence of a mass kill strategy, whereby the migrating herd would be run into traps, or off a cliff (Legge and Rowley Conwy 2000). Such practices using specialised 'desert kite' structures have been noted from travellers' tales as late as the early twentieth century (Mendelssohn 1974). However there is nothing that could support the notion of desert kites being constructed before the emergence of state-level societies (Zeder *et al*. 2013). Nevertheless, local topography, or even indiscriminate patterns in individual hunting, could produce similar results. In the case of Persian gazelle migrations such indiscriminate hunting would not be sufficient to depress the populations – otherwise the species would be wiped out long before the introduction of rifles triggered their demise in the twentieth century. However, what needs to be taken into account is that the migration patterns might have changed with time, as the climatic changes of the Late Pleistocene changed the water availability throughout the Levant, which makes the assumption of the constancy of migration throughout the Late Pleistocene questionable (Martin 2000). Nevertheless, it is plausible to assume that the seasonal availability of large gazelle herds facilitated the formation of large gatherings, which over time led to the formation of scatters in excess of 10,000 m^2. Given the diverse origins of the finds found at Kharaneh IV, it is also plausible to assume that these aggregations would be a meeting point for groups usually following itineraries in different parts of the Near East and maintaining different networks further afield.

Persian gazelle is a fairly large ungulate, carrying a significant amount of meat in large herds, which makes it a good prey species. Mountain gazelle offers smaller returns, is more difficult to hunt and occurs in smaller herds. Seen from this perspective, the focus on the gazelle seen at sites west of the Jordan is surprising. Here two alternative hypotheses are possible: the excessive hunting pressure led to the depletion of other fauna, or there was a symbolic value attached to the species throughout the Epi-Palaeolithic of the 'Natufian homeland'. Given the impossibility of applying mass kill tactics to Mountain gazelle herds, the increased proportion of juveniles at Hatoula may indicate stock depletion and, by proxy, depletion in numbers of other species (Davis 2005). The symbolic interpretation is supported by burials with gazelle horn cores being a recurring feature from the Kebaran Ein Gev I to the Natufian ones at Ain Mallaha (Verhoven 2004). These two scenarios are not mutually exclusive and potentially more complicated factors that we do not yet understand were also at play.

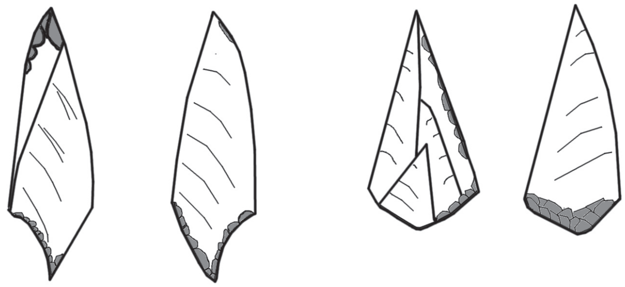

Figure 12.5. Harifian points. Illustration by P. Jacobsson based upon Goring-Morris (1991, figure 17).

Gazelle, people and projectile points

The few archaeozoological studies in the Sinai and the Negev indicate that these regions were found to be gazelle-poor compared to their northern counterparts. It is within this context that the projectile points re-emerge for the first time since the early Epi-Palaeolithic as a defining feature of a local Harifian industry (Figure 12.5; Goring-Morris 1991; Marks 1973). The terminal Epi-Palaeolithic origin is supported by the available radiocarbon dates from the few excavated sites, which places the Harifian towards the end of the eleventh millennium cal. BC (Figure 12.6). The Harifian either dies out or, more likely, transforms into the southern variant of the PPNA encountered at Wadi Feynan 16, which is also gazelle-poor (Finlayson *et al*. 2011b). The area covered by the Harifian is about 20–30,000 km^2, and includes both the low-lying desert areas of the Sinai and the ridges of the Irano-Turanian highland zone. The cultural importance of this geographical difference is substantiated in the settlement record, which alternates between locales with substantial architecture in the uplands (*e.g.* Abu Salem, see Marks and Scott 1976) and the more ephemeral stations in the Negev (*e.g.* Nahal Lavan 110, cf. Phillips and Bar-Yosef 1974). Goring-

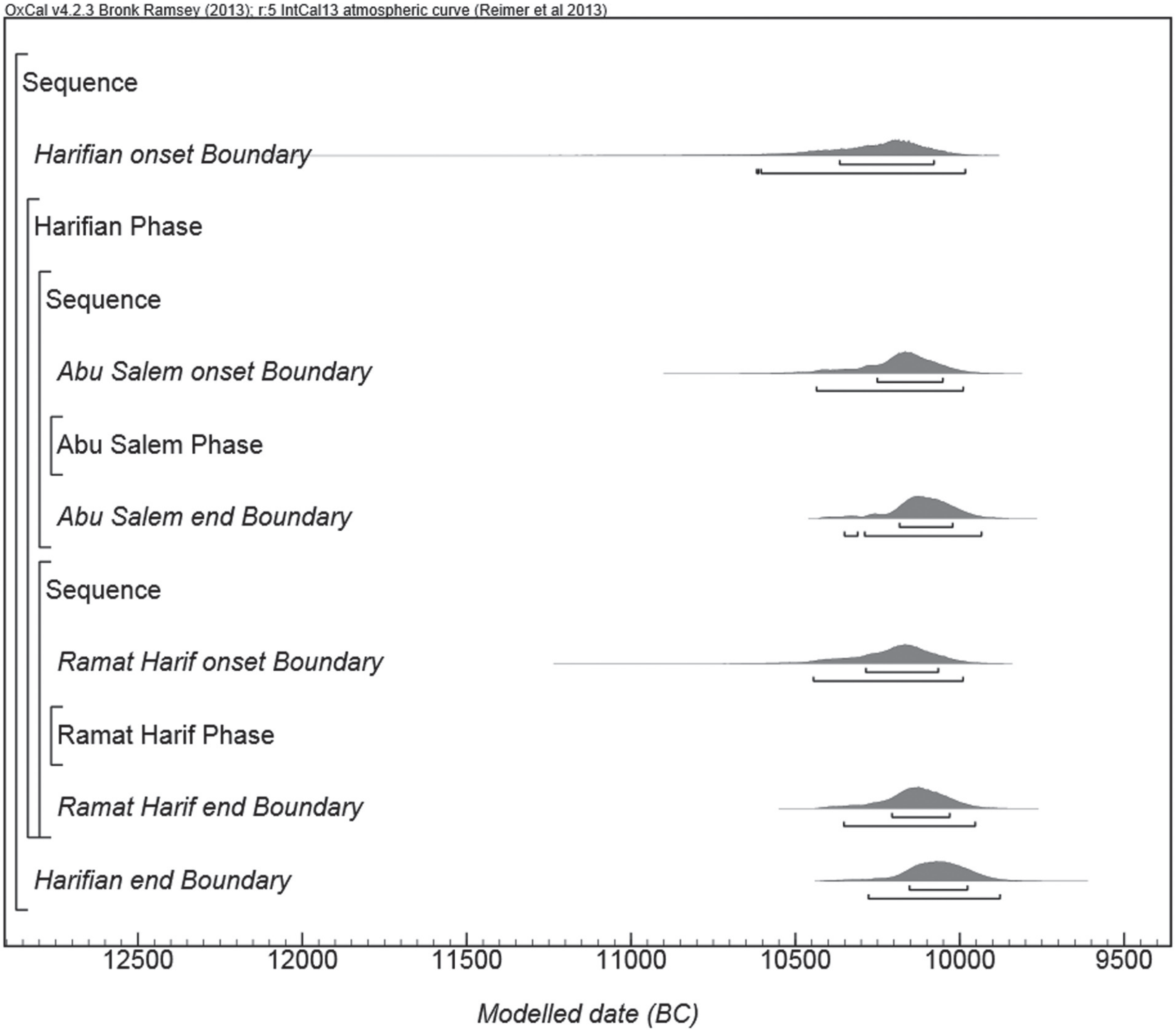

Figure 12.6. The chronological extent of the Harifian, constrained by the radiocarbon data from the PPNA WF-16. Data from Goring-Morris (1991). Sites with less than four measurements have been rejected, leaving only Abu Salem and Ramat Harif. All the Harifian radiocarbon determinations are subject to outlier analysis to account for the old wood effect (Bronk Ramsey 2009). This model is based on considering the two sites as uniform phases (Buck et al. *1994) due to lack of sufficient information on site formation and stratigraphy.*

Morris (1991, 209) estimates the Harifian population to have been up to 500 individuals at any one time. While prehistoric demography is riddled with speculation, this falls within the expected size of a dialectic fission-fusion group, as known from modern hunter-gatherer ethnography (Layton *et al*. 2012, 1238).

The Harifian points were a local development that failed to disperse over the Levant and correlates with low frequencies of gazelle in the faunal assemblage. This is surprising, given that the Harifians were involved in exchange networks reaching as far as Anatolia (obsidian from Gollu Dag was found at Shunera X, see Goring-Morris 1991, 185). Arrowhead dispersal begins only with the onset of the PPNA (Gopher 1994). Within time-scales that are indiscernible by currently available radiocarbon record the projectile point technology developed and dispersed throughout the Levant. Therefore, it is apparent that it took only a few generations for it to become a fixture of assemblages found throughout the Near East. The exceptions are found at the northern extremes of the PPNA distribution on sites, such as Kortik Tepe or Hallan Cemi (Ozkaya 2009), which are almost devoid of gazelle (Arbuckle and Ozkaya 2006). This suggests an association between the projectile

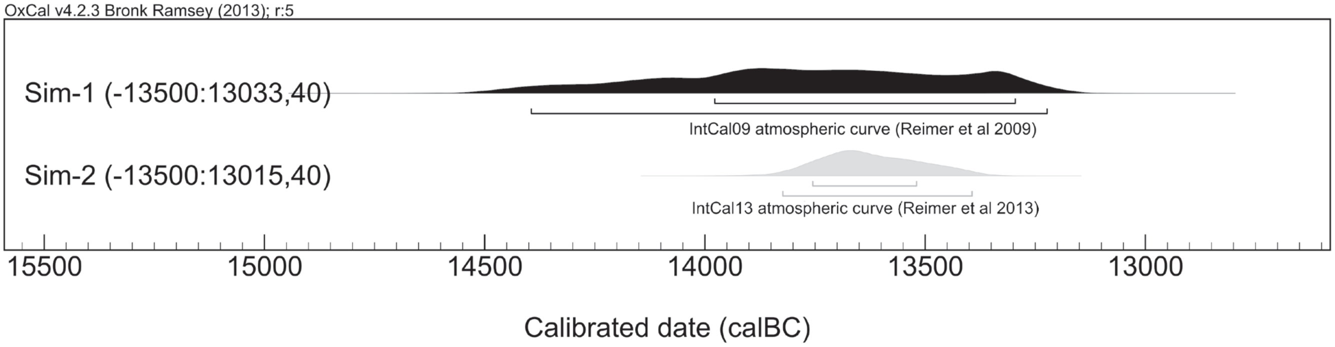

Figure 12.7. A simulation of a ^{14}C determination from the year 13,500 cal. BC calibrated under the curves IntCal 09 and IntCal13.

point and gazelle hunting during the period when the slow materialization of culture during the late Epi-Palaeolithic has escalated to monumental proportions with the towers of Jericho and Qaramel (Mazurowski *et al*. 2009), or the enclosures of Gobekli Tepe (Schmidt 2010). Why would this change take place at this time, given that for perhaps as long as half a millennium projectile points were confined to a small area at the edge of the Levant?

The simplest hypothesis is that increased human population pressures led to the depression of the gazelle herds, suggested within Davies' hypothesis. Here the projectile points could be seen as a means of using a material referent to fill in an ideological void. This way, the importance of hunting to human life-ways could be maintained, albeit in changed form. As the projectile points joined the new PPN network, they contributed to the formation of new aggregation sites, such as Gobekli Tepe. Thus, in a way, the hunter-gatherer ideology contributed to Neolithisation. The main problem of the simple scenario is that it relies on the depletion of gazelle throughout the region, which is not unanimously supported by the archaeological evidence.

Any simple scenario of the type discussed above will suffer on account of regional diversity. For this reason, the understanding of the particular communities and the interconnections between them is paramount to a thorough understanding of the processes of change at the end of the Epi-Palaeolithic. It is at this point that the ambiguities in the data begin to constrain our ability to draw inferences, but at the same time we are getting closer to relating these 'historical' discussions to particular material record, rather than generalising models of change.

This is because we are no longer trying to extrapolate over the entirety of the Near East and so the interpretations of particular finds are returned to their original contexts. For example, the scenario proposed by Davis, may well be applicable to Hatoula and the surrounding areas. At the same time there is no need to apply this model to Qaramel, or Mureybet, each one of which lies in a different eco-zone, with the local communities involved in very different projects. This does not preclude the impacts of cultural changes throughout the interaction network, or the major environmental changes. It would be unreasonable to pre-suppose that the migration routes of the Persian gazelle would remain unchanged in the face of the Younger Dryas, or the post-Dryas recovery. Therefore, it would be equally unlikely to assume that the itineraries and therefore the practices of the communities hunting the gazelle would remain unchanged. The dispersal of the projectile point technology would have most likely been the result of a series of synchronized local changes, positively feeding back into each other throughout the network.

Unfortunately, we are only in a position to begin the evaluation of such hypotheses for the Epi-Palaeolithic at the moment, as it is only within the past five years that the tools for attaining the kinds of chronological resolution needed to test synchronicity of events became available. Three crucial advances that make this possible are the routine attainment of radiocarbon measurements of less than 50 years, development of an atmospheric calibration curve for the terminal Pleistocene, and advances in dating bio-apatite. The issue of limited precision of individual determinations became apparent during the attempts to date Ohalo II in the early 1990's. Because all of the measurements had standard errors of over 100 years, what was in the excavators' opinion a site which lasted a few decades at most, became diffused to a few millennia (Nadel *et al*. 1995). The improvement of the Pleistocene radiocarbon calibration with IntCal13 is another point of interest. Until 2013, virtually all of the calibration for the period was conducted against a 'marine curve' based on Uranium/Thorium dated corals (Fairbanks *et* *al*. 2005). This procedure meant that the curve carried over the uncertainties of the U/Th method besides the ^{14}C uncertainties and so the precision of calibrations was much lower (Figure 12.7a, see Reimer *et al*. 2009). With the advent of IntCal13, there is an addition of the varve record from Lake Suigetsu, which limits the uncertainty from this source (Figure 12.7b, see Reimer *et al*. 2013). Finally, advances in the dating of inorganic bone fractions (Zazzo and Saliege 2011), might make it possible to use radiocarbon dating for sites which hitherto could not be dated because of lack of surviving collagen, as at Nahal Hadera V (Godfrey-Smith *et al*. 2003).Until these advances become widely applied, however, our understanding of the processes discussed throughout this paper will be conjectural.

Nevertheless, certain observations seem robust at this point. Firstly, there is strong evidence that gazelle were important to the formation and maintenance of human sociality throughout the Epi-Palaeolithic, although their contribution would have varied in accordance with species ecology. Through this we also know that the Epi-Palaeolithic technology was suitable for hunting gazelle. Secondly, the projectile points of the PPNA dispersed rapidly, but only in the areas with long traditions of gazelle hunting. Therefore, we can make the general assumption that the Epi-Palaeolithic tradition provided the ratchet by which a Neolithic hallmark disperses and reproduces itself. The only way to verify this assumption, however, is to test how it functions in particular local contexts.

Conclusion

This chapter discussed the emergence of an ideological connection between gazelle and projectile points at the end of the Epi-Palaeolithic and the onset of the Neolithic. It was argued that the origin of this process lies in the changing relationships between humans and their surroundings through the Epi-Palaeolithic, although the detail of these transformations is elusive due to the scale of the phenomena in question. Nevertheless, there are some trends, such as correlation of site sizes with different gazelle species present in the area. What is striking is that these animals constitute a substantial part of the archaeozoological assemblages throughout much of the Near East, despite major differences in the ecological background. It is then argued that this long-term tradition was also an important factor in the dissemination of the new projectile point technology, albeit in each region this would probably be the result of different motivations.

Such connections are essential to a thorough understanding of the wider problem of why did hunter-gatherers in some cases choose to Neolithise. In the case of the Near Eastern projectile points, which are closely associated with the Neolithic, it appears that the changes to long-term tradition of gazelle hunting and its associated ideological changes could have played a significant part. The actual processes for how this took place, however, would have been different at each node of the PPN interaction zone. A thorough understanding of the problem will require major advances in Epi-Palaeolithic chronology, which will allow synchronising of discrete events in particular places across this interaction zone.

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13. Animal Exploitation Strategies in Eastern Aquitaine (France) during the Last Glacial Maximum

Jean-Christophe Castel, Myriam Boudadi-Maligne, Sylvain Ducasse, Caroline Renard, François-Xavier Chauvière, Delphine Kuntz and Jean-Baptiste Mallye

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Abstract

Southwest France is well known for its high density of Upper Palaeolithic sites. The main concentration extends from the Charente to the Vézère valley. The Quercy is a marginal zone extending the boundary to the southeast. This last area seems not to have been inhabited after the early stages of the Aurignacian, and recolonisation began slowly during the Gravettian. The best documented period for the eastern edge of Aquitaine is the first part of the Last Glacial Maximum and the assemblages attributed to the Recent Solutrean and the Badegoulian. Reindeer is the preferred prey of hunters at all these sites. However, the secondary species are exploited differently in different regions and techno-complexes.

Data from natural traps sheds new light on human hunting strategies. In Quercy, for example, it has been shown that far from being rare, certain species that were not hunted were actually abundant in the surrounding area. Hunting is slightly more diversified in northern Aquitaine than in the south-east, and it seems probable that a large biomass was available throughout the regions studied. The choices made by hunters during the Recent Solutrean and the Badegoulian are, therefore, not simply a systematic exploitation of the entire animal biomass available. This information prompts a re-examination of our assumptions about human occupation strategies.

Introduction

In order to characterise the technical and economic behaviour of Palaeolithic populations, it is essential to know which behaviours are the result of constraint and which are deliberate choices. Only then is it possible to recognise specific characteristics that apply only within a limited area or time period. Furthermore, the inferences drawn from the analysis of Palaeolithic behaviour will vary depending on the spatial and temporal frameworks chosen. Large-scale studies of the European Palaeolithic generally group together assemblages that formed in very different contexts and were excavated at different periods during the development of our discipline. The heterogeneity of data often means that only very general characteristics can be deduced. To avoid this pitfall, smaller time and space windows are used in order to select only precise characteristics that are uniform for each assemblage.

Our study concerns part of south-west France, on the eastern edge of the Aquitaine basin. We take the Last Glacial Maximum to be the maximum extent of the icecaps, excluding the H1 and H2 events (Clarke *et al*. 2009; MARGO Project 2009; Mix *et al*. 2001). Our analysis, which consists of the examination of hunting strategies and the exploitation of prey, is combined with an investigation of the faunal context in which these choices were made. We compare the faunal spectra of the archaeological sites with faunal remains that accumulated without human intervention. These natural traps indeed provide an insight into the environment that has hitherto been undervalued.

Revision of the biological and geomorphological framework of prehistoric populations allows us to examine the choices made by hunters. How far were the technical practices (*i.e.* techniques and hunting equipment) of these groups dependent on external constraints or cultural tradition? Although this paper is essentially zooarchaeological in approach, interdisciplinary studies are currently underway to shed more light on technical (lithic and bone industries) and symbolic (ornaments, *etc.*) production.

The Palaeolithic during the Last Glacial Maximum in south-west France

General context

The geomorphology of south-west France has conditioned the spatial distribution of sites discovered during the last 150 years, and structured our research and way of understanding the diversity of human behaviour. Three main regions of habitation may be identified for the Upper Palaeolithic: the Pyrenees, the eastern edge of the Aquitaine Basin (Charente-Périgord-Quercy), and the Bordeaux region (Entre-Deux-Mers).

Links between the Pyrenees and the eastern edge of the Aquitaine Basin have been observed mainly through the circulation of lithic raw material and/or particular objects, such as items of ornamentation (Taborin 1993, 2004). Moreover, recent research has shown the existence during the Upper Palaeolithic of an area between these two zones that was unfavourable to the development of biomass and had a low density of human occupation (*i.e.* Sable des Landes: Bertran *et al*. 2011, 2012; Garonne Valley: Bruxelles and Jarry 2011). During the first half of the Last Glacial Maximum, the period selected for this study, large differences are apparent between the geographical zones on either side of this largely deserted area. During the Recent Solutrean the typology of lithic points demonstrates marked regional identities, whilst during the Badegoulian lithic tools are homogenous throughout the area of their distribution. Recent studies of lithic production have shown significant differences between the Recent Solutrean (Renard 2008; Renard and Geneste 2006) and the Badegoulian (Ducasse 2010, 2012). Apart from the typological differences that have long been known, the earliest Badegoulians may be distinguished from their Solutrean predecessors mainly from a techno- and socio-economic perspective. Hunting practices display considerable differences in terms of the type of weapons used and, particularly, in their economic management (Ducasse and Renard 2012).

The sites studied in this paper are spread over the eastern edge of the Aquitaine Basin, forming an ellipse of 200 by 50 km (Figure 13.1). For both the Recent Solutrean and the Badegoulian, the fifteen or so sites studied are evenly spread, with clear clustering along the main watercourses. All of the sites fall below an altitude of 350 m. The calcareous environment plays an important role in the availability of silicic raw materials, as well as the structure of the relief and, therefore, the modes of travel possible. To the north, from Charente to the Loire, the density of sites diminishes. Despite the strong technical and 'stylistic' consistency of the artefacts, this region was not included in the study due to the scarcity of faunal data, which may correspond to a lack of research or different settlement motivations. To the south, the Aveyron catchment situated around Bruniquel was scarcely occupied, except at the end of the Last Glacial Maximum (only the Gandil site yielded a significant faunal finds).

The geographical area comprising Charente, Périgord, and Quercy has been treated as a single unit for over a century (see the work of Peyrony or Cheynier), and provides a very good laboratory for the time-dependent study of subsistence behaviours. Given the considerable differences observed in the management of lithic hunting equipment between the Recent Solutrean and the Badegoulian, it now seems reasonable to consider how these differences were expressed in the methods and strategies for exploiting prey, particularly within an area for which we broadly understand the constraints (topography, animal and mineral resources, *etc.*)

Methodological biases and the approach adopted: old collections and recent global zooarchaeological studies

Zooarchaeological studies have developed greatly over the last 15 years (*e.g.* Castel 1999, Costamagno 1999, Laroulandie 2000). Most of the series is old, and the collecting conditions limit the kind of analyses that can be carried out so they cannot provide as much detail as some of the more recently excavated sites (Figure 13.2, Tables 13.1 and 13.2). Other recent studies made in this region, but focussing on different periods, have seen the development of analyses based on animal ecology (Grayson and Delpech 1998, 2002). These have mainly dealt with the Middle and early Upper Palaeolithic. Richness and diversity indices have been used to define the environment and choices of Palaeolithic populations. However, a number of difficulties are encountered as one approaches the Upper Palaeolithic.

It has recently been observed that in many assemblages the taxa present are not the result of local hunting for food. For example, at Combe Saunière during the Solutrean, the only evidence of ibex is three incisors, two of which are pierced. The third may have been transported to the site either as part of an ornament, or with the intention of using it for ornamentation (Castel 1999, 2010; Castel *et al*. 2006). During the Solutrean at Cuzoul de Vers, the only horse (*Equus caballus*) remains are in the form of shaped and well used retouchers. Once again, the horse bones may have been transported over considerable distances. In

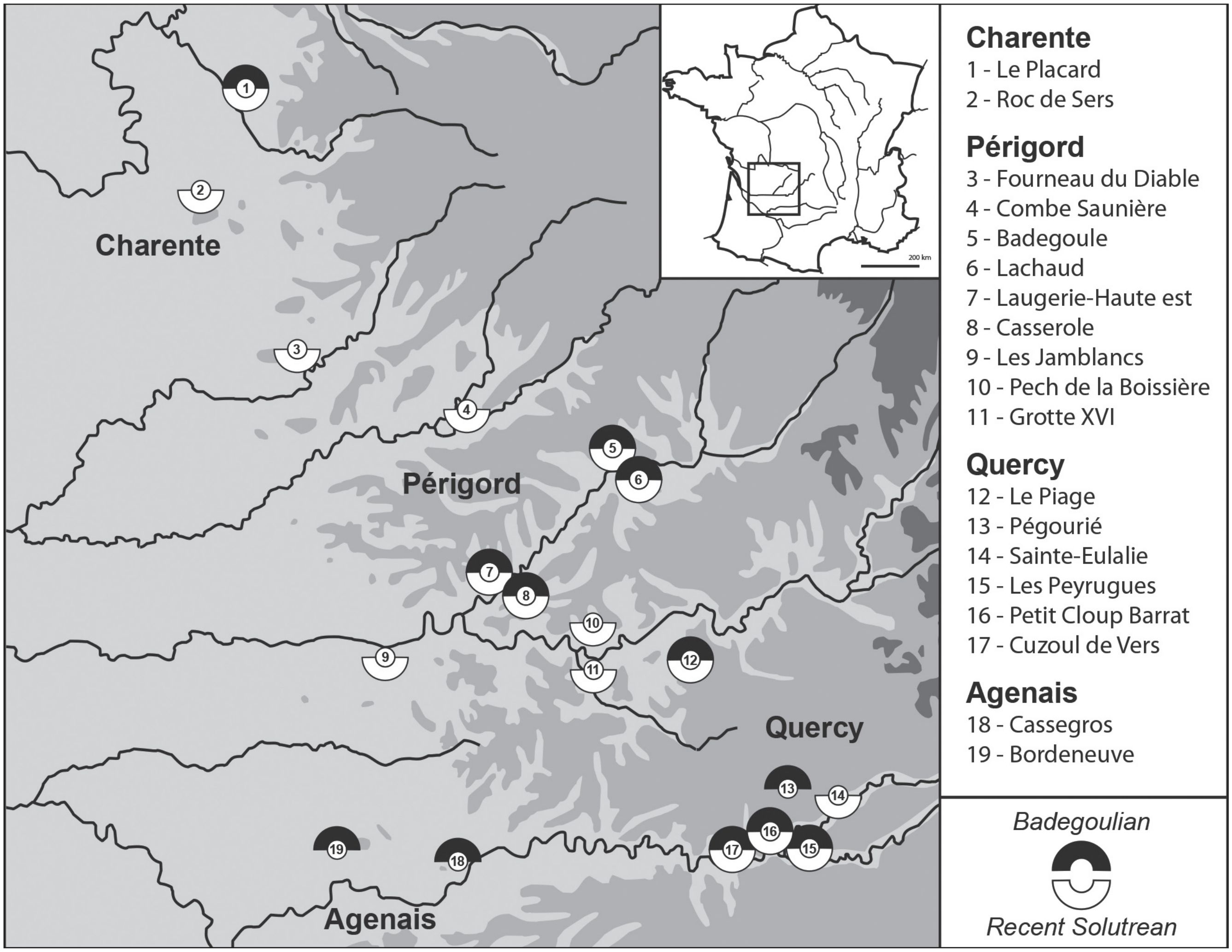

Figure 13.1. Distribution of sites from the Recent Solutrean and Badegoulian with significant faunal assemblages. The names of the sites are indicated in Tables 13.1 and 13.2.

the Badegoulian sector of the same deposit we see a clear over-representation of incisors, both pierced and non-pierced, from bovines (Bos or Bison), chamois (*Rupicapra rupicapra*) and ibex (*Capra ibex*). While the last two taxa may have been hunted locally, the same is not true for the bovines (Castel 2003, 2010, 2012). In the Badegoulian and Solutrean layers at Peyrugues (Juillard 2009), the same situation is found (Castel *et al*. 2014). All incisors and canines, and certain categories of bone tools, should therefore be excluded from analysis of the faunal spectra. Calculations of evenness, which are based on the number of non-overlapping taxa in the assemblage (Grayson 1984), are thus not possible for most of the sequences studied. The status of taxa in an assemblage must first be ascertained in more detail, in order to retain only those resulting from local hunting. Calculations of the diversity of an assemblage, on the other hand, are based on the relative abundance of different taxa, and so avoid this issue.

The main problem concerns the old, legacy collections. The bones available to us today were selected over 50 years ago, using outmoded criteria; they are also the bones that have resisted the passage of time. The criteria used by archaeologists in Aquitaine before 1970–1980 generally lead to the following biases:

1) Unusual or remarkable species were over-sampled for the purposes of paleontological studies (so well-known species such as reindeer and horse are under-represented).
2) Small skeletal bones from species smaller than reindeer were not collected. Species where the joints were not used for combustion or grease rendering are over-represented. These are the ones that are least used or more difficult to work and thus potentially the small

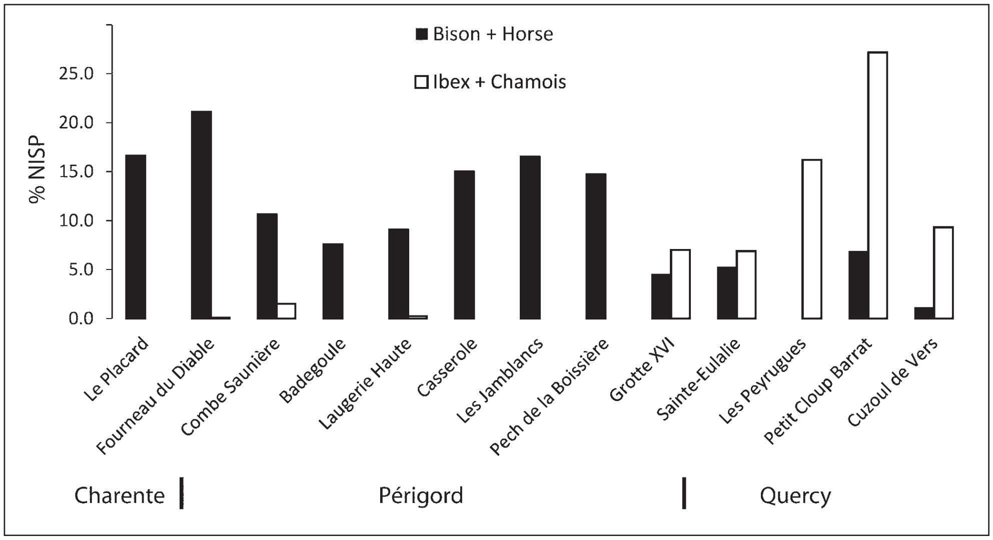

Figure 13.2. Frequencies of secondary prey species (%NISP) in Recent Solutrean sites.

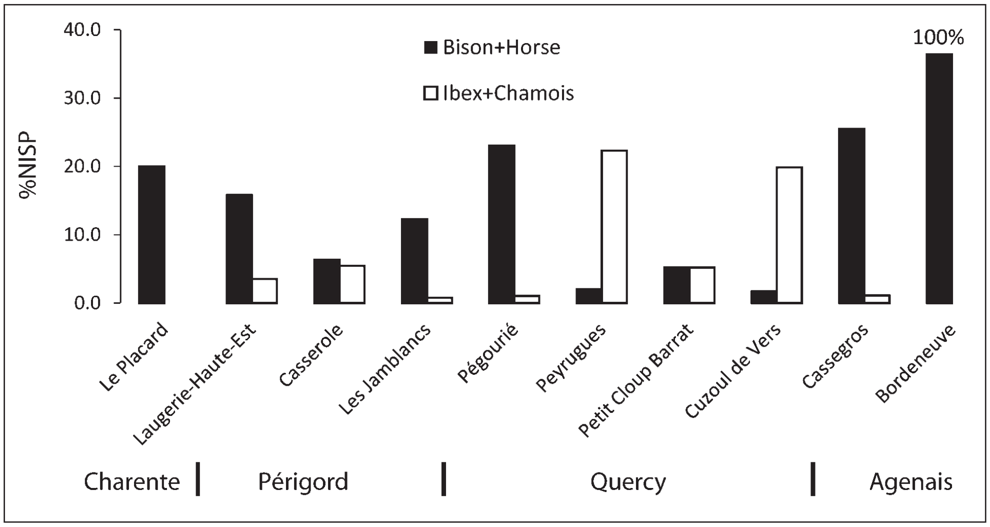

Figure 13.3. Frequencies of secondary prey species (%NISP) in Badegoulian sites.

and largest animals. The scale of the problem should be assessed before analysis.

3) Destructive analytical techniques were not always noted, for example cementochronology, which may have reduced the number of jugal teeth of reindeer in comparison with those of horse, which are less suitable for this analysis.

Assessment of the diversity of an assemblage is thus dependent on an understanding of the excavation and sampling methods used. We have nonetheless used diversity indices, such as Simpson's Index, for each assemblage ($D=\sum n_i[n_i-1]/N[N-1]$, where ni=the number of specimens in the ith species and N=the total number of specimens, after Grayson 1984). Following Grayson, we "chose this index because it more sensitively reflects the dominance of an assemblage by a single species than does the Evenness. The values we report are the inverse of Simpson's Index: the lower the resultant value, the more the assemblage involved is dominated by a single taxon (Magurran 1988)" (Grayson and Delpech 1998). Because of these preservation disparities for the faunal remains in collections relating to the main habitation sites in south-west France, we have used a quantified analysis based on the number of remains currently conserved in the collections, but we have also taken into consideration non-quantified data such as the nature of the excavations and the representativeness of the samples.

The prey of hunters during the Last Glacial Maximum

A number of paleo-environmental reconstructions (Banks *et al*. 2008, 2009 and 2011) model the variations in climatic conditions for the Last Glacial Maximum. Their results provide information on climatic conditions at the supra-regional level (50 to 100 000 km^2), a larger scale than that at which we have decided to work. They do not (yet) produce sufficient detail to explain the convergences and diversities observable at the infra-regional scale (*i.e.* 20 to 50,000 km^2). And although the general climatic framework is becoming clearer, little more is known about the response of the ungulates, their dispersal and migrations.

In almost all the sites, examination of the Recent Solutrean and Badegoulian assemblages reveals reindeer as the most important species. With a few exceptions, mentioned below, this species represents over 70% of the identified remains. More interesting is the importance of the other ungulates (see Figure 13.3). We recognise two guilds: the first, associated with open arctic habitats, is characterised by large ungulates, bison, and horse; the second, which corresponds to steeper habitats in the south east of the region, features ibex and chamois. We have excluded red deer from the analysis, because its presence in the harshest phases of the Last Glacial Maximum still needs to be evaluated in light of what is known about their current ecological requirements.

The frequency of the secondary ungulates is different in the two techno-complexes. We were able to compare sixteen sites from the Recent Solutrean (Table 13.1). Hunting of bison and horse plays an important role in Charente and the north of Périgord. Saïga antelope is also present at many of these sites. Quercy is best illustrated by recently excavated sites such as Cuzoul de Vers and Les Peyrugues, which yielded exhaustive samples. They show the relative abundance of ibex and chamois hunting, the absence of bison hunting, and the rarity of hunting of horse (Castel 1999, 2003, 2010, 2012; Juillard 2009). It seems likely that Solutrean hunters supplemented reindeer by exploiting different ecological niches: plains rich in large ungulates to the north, and slopes favourable for rupicolous ungulates in the south.

It should be noted that the site at Laugerie-Haute presents problems concerning the consistency of sequences (Bertran and Texier 1995; Castel and Madelaine 2006; Delpech 2012; Renard 2010; Texier 2006), so we have taken an average of the percentages for the eastern and western sectors in order to minimise problems due to uncertainties about post-excavation classification. Considerable hunting of chamois is evident at the Combe-Saunière site. This may be due to the undulating terrain that stretches towards the Massif Central. Cave XVI, in the south of Périgord, also shows an abundance of Caprinae. This may be a consequence of the rising terrain, but it should be noted that the finding is based on a small number of remains without anatomical precision. The reliability of several Quercy sites is similarly limited due to small sample size.

For the Badegoulian, thirteen sites were compared. Reindeer still predominate, and the role of secondary prey is aligned along a northwest/southeast axis, similar to the Recent Solutrean (Table 13.2). However, this is based on a smaller number of sites, and the distribution of sites is more dependent on the relief of the terrain. Three sites are noteworthy. Pégourié, with bison hunting, is located in the centre of Quercy in a sector with higher altitude (335 m) but less pronounced relief than the other Quercy sites. Therefore, bison may have been hunted to compensate for the lack of rupicolous ungulates. More large ungulates are found at Cassegros, located westward on the plains. Only bison are present at Bordeneuve, further to the west, though considerable taphonomic bias is suspected (Ferullo *et al*. 1999). Unlike the Solutrean, it seems that differences in the relief of the terrain dictate the role of secondary ungulates in the diet.

Human occupation and methods of prey exploitation

Human economic organisation is reflected in the way the ungulate carcasses are exploited. Unfortunately, the butchery techniques used are not well known, as most excavations were carried out too long ago to allow for analysis of the finds. An interesting exception is the site at Cuzoul de Vers, with around 30 Badegoulian and Upper Solutrean levels (Clottes *et al*. 2012). The main species is reindeer, with chamois and ibex systematically, and horse occasionally, present. In each level, the number of prey was less than ten. The butchery practices present remain exactly the same from the bottom to the top, across a period of about a thousand years (Castel 2003, 2010, 2012).

We can also demonstrate systematic use of spongious bone as fuel at this site (Castel 2003, 2010, 2012; Costamagno *et al*. 2009; Théry *et al*. 2009). This is associated with percussion of the diaphyses at the periphery of the joints for marrow extraction and the removal of entire joints for burning. Similarly, the vertebral bodies were separated from the spinous and transverse processes and the ribs broken near the joints. In Charente, the deposits at Le Placard, which was occupied during the Upper Solutrean and the Badegoulian, show many points in common with Cuzoul de Vers, notably the selective burning of

Sites	**Number on Figure 13.1**	**Faunal study**	**Recent/Ancient fieldwork**	***Bovinae (Bos or Bison)***	***Equus caballus***	***Cervus elaphus***	***Rangifer tarandus***	***Capra ibex***	***Rupicapra rupicapra***	***Saiga tatarica***	***Sus scrofa***	***Capreolus capreolus***	**Total**	**% Reindeer**	**Diversity (D, Simson Index)**	**Dominance (1/D)**
Le Placard	1	Griggo unpublished	R	8	369		1891			37			2305	82.0	0.70	1.43
Roc de Sers	2	Brugère 2003; Henri-Martin 1928	A	x	1745	x	1st rank	x		x			>3600	>50%		
Fourneau du Diable	3	Fontana 2001; Madelaine 1989	A	15	639	12	2441	2		26			3135	77.9	0.65	1.54
Combe Saunière	4	Castel 1999	R	92	513	43	4998	3	83	44	1		5777	86.5	0.76	1.32
Badegoule	5	Cheynier 1949	A	43	900		11500	yes					12443	92.4	0.86	1.16
Lachaud	6	Cheynier 1965	A		xx		xxxx							>60%		
Laugerie Haute ouest, levels 2 to 7	7	Delpech 1983	A	1	12	3	1389						1405	98.9	0.98	1.02
Laugerie Haute est, l. 22+23+ 'Sol sup'	7	Delpech 1983	A		36		172	1					209	82.3	0.71	1.42
Casserole, level 7	8	Castel unpublished	R	1	11		68						80	85.0	0.74	1.35
Les Jamblancs	9	Madelaine in Drucker *et al*. 2000	R	12	58	8	354			1			433	81.8	0.69	1.46
Pech de la Boissière	10	Madelaine unpublished	A	4	1	6	29			1			41	70.7	0.52	1.92
Grotte XVI à Cénac	11	Grayson *et al*. 2001	R	4	12	18	316	12	13		4	1	380	83.2	0.70	1.44
Le Piage	12	Castel and Morin (fieldwork in progress)	R				xxxx							>70%		
Sainte-Eulalie	14	Delpech 1983	A	2	1	1	51	3	1				59	86.4	0.75	1.34
Les Peyrugues	15		R			1	31	3	3				38	81.6	0.67	1.49
Petit Cloup Barrat, level 8a	16	Castel (fieldwork in progress)	R		7		12	5					24	>60%	0.51	1.96
Cuzoul de Vers	17	Castel 1999	R		2		173	7	11				193	89.6	0.81	1.24
Global regional proportions (%NISP) (except 2, 6, 12)				0.6	15.2	0.3	83.0	0.1	0.4	0.4	0.0	0.0	100.0	83.0		

Table 13.1. Number of remains (NISP) and information on the main ungulates in Recent Solutrean sites from Eastern Aquitaine. Notes for Solutrean sites: for D calculation and % reindeer: 8. we included 48 'reindeer or ibex' attributed to reindeer because ibex is absent; 16. we included 79 'reindeer or ibex' distributed between both taxa in relation with their proportions; 12. Badegoulian and Recent Solutrean are mixed in approximately equal proportions; 15–17. without incisors and canines; 12 and 16. fieldwork in progress, provisional data. Excavations and collections are provided by: 1. J. Clottes, L. Duport and V. Féruglio; 2. L. Henri-Martin; 3. D. Peyrony; 4. J.-M. Geneste and J.-P. Chadelle; 5 and 6. A. Cheynier; 7. F. Bordes; 8. L. Detrain et al.; 9. J.-J. Cleyet-Merle; 10. collections of the Musée National de Préhistoire, Les Eyzies; 11. J.-P. Rigaud and J. Simek; 12. J.-G. Bordes and F. Le Brun; 13. M.-R. Séronie-Vivien; 14. M. Lorblanchet; 15. M. Allard; 16. J.-C. Castel and F.-X. Chauvière; 17. J. Clottes and J.-P. Giraud; 18. J.-M. Le Tensorer; 19. O. Ferullo and A. Lenoble.

Sites	Number on Figure 13.1	Faunal study	Recent/Ancient fieldwork	*Bovinae* (*Bos* or *Bison*)	*Equus caballus*	*Cervus elaphus*	*Rangifer tarandus*	*Capra ibex*	*Rupicapra rupicapra*	*Saiga tatarica*	*Sus scrofa*	*Capreolus capreolus*	Total	% Reindeer	Diversity (D, Simson Index)	Dominance (1/D)
Le Placard	1	Griggo unpublished	R	43	511	4	2216	1		50			2825	78.4	0.65	1.54
Badegoule	5	Cheynier 1949	A	x	xxx		xxx		x	x			0	>50%		
Lachaud	6	Cheynier 1965	A	x	x		xxxx	?	x				0	>75		
Laugerie-Haute-Est (Magd. 0+I)	7	Delpech 1983	A	13	138	5	1446	12	28	5			1647	87.8	0.78	1.29
Casserole, Recent Bad.	8	Castel unpublished	R		21	4	246	9	7	2			296	83.1	0.72	1.40
Casserole, Ancient Bad.	8	Castel unpublished	R		1		17	1					19	89.5	0.80	1.26
Les Jamblancs	10	Drucker *et al*. 2000	R	1	15		113		1	1			131	86.3	0.76	1.32
Le Piage	12	Castel & Morin (fieldwork in progress)	R				xxxx							>70%		
Pégourié	13	Séronie-Vivien 1995	R	430	64		1626	13	9		5	6	2257	72.0	0.56	1.79
Les Peyrugues	15	Juillard 2009	R		2	28	457	69	17			2	575	79.5	0.65	1.54
Petit Cloup Barrat	16	Castel (fieldwork in progress)	R		4		69	4					77	89.6	0.81	1.24
Cuzoul de Vers, Recent Bad.	17	Castel 1999/2010	R	15	42	15	1025						1489	68.8	0.51	1.96
Cuzoul de Vers, Ancient Bad.	17	Castel 1999/2010	R	5	3	3	2650		96				2901	91.3	0.84	1.19
Cassegros, level10	18	Castel (analysis in progress)	R	41	48	4	259	4		1			357	72.5	0.56	1.80
Bordeneuve	19	Madelaine in Ferullo *et al*. 1999	R	182	1								183	0		
Global regional proportions (%NISP) (except 5, 6, 12 and 19)				5.7	6.7	1.3	79.4	3.9	2.4	0.5	0.0	0.1	100.0	79.4		

Table 13.2. Number of remains (NISP) and information on the main ungulates in the Badegoulian sites of Eastern Aquitaine. Notes: 10. slope deposit (Pente 2 + Ouest 2) has low reliability; 12. Badegoulian and Recent Solutrean are mixed in approximately equal proportions; 13. probably mixed with underlying level; 15 to 18. without incisors and canines; 19. very poor preservation.

spongious bone (Griggo, n.d.; Costamagno *et al*.1999). No other site provides quite so much detail (although see Castel *et al*. 2006 concerning Combe-Saunière).

The huge Laugerie-Haute site, occupied mainly during the Solutrean, is often treated as an aggregation site of the sort described by Conkey (1980, 1992). However, a comprehensive study of this assemblage, which was excavated many years ago, is needed to learn more about the possible origins of human occupation and how the faunal remains reflect this.

A new approach – the importance of natural sites in the discussion of hunting strategies

Natural traps: a new window on the environment

It no longer seems reasonable to consider the fauna of archaeological sites as an exact reflection of the natural animal community. Other methods must therefore be found to understand the environment. This leads us to consider the information provided by natural traps.

Level	*Mammuthus*	*Dicerorhinus*	*Bos or Bison*	*Equus caballus*	*Cervus elaphus*	*Rangifer tarandus*	*Capra ibex*	*Rupicapra rupicapra*	*Saiga tatarica*	*Canis lupus*	Leporids	*Pyrrhocorax graculus*	Total	N sample	Limits (BP)		Average Age (BP)	Average Age (CalBP) rounded
2			54	9	172	1				1	76		313	2	10440	10650	10545	10500
2L			3	7	9	15					86	29	149	1	10520		10520	10465
3			83	217		392	1		1	18	60	18	790	4	13360	15350	14212	15100
4			**163**	**300**		**615**			**2**	**44**	**172**	**114**	**1410**	**7**	**15840**	**17990**	**16930**	**18800**
5	**2**		**115**	**130**	**1**	**574**	**3**			**5**	**314**	**251**	**1393**	**3**	**19290**	**20290**	**19657**	**21500**
6	2	1	36	51	1	118		2		5	197	125	535	*	>20040		>20040	>22000

*Table 13.3. Igue du Gral (Sauliac-sur-Célé, Lot, France). Number of remains (NISP) of the main taxa in a sample (squares P46, P47 and Q47) and average age of the deposits. * = Actually under discussion.*

These vertical cavities are present throughout the study region, particularly in Quercy (Coumont 2009), and around 50 of them contain Pleistocene deposits.

Some of the traps operated for only a short time and contain few individuals and thus provide a snapshot of the environment over a brief period. Others contain a large number of individuals that may have accumulated over a longer period. The most interesting sites are those with horizontal paleontological layers, but these are very rare. It is clear that different species are not trapped at the same rate. This would depend, for example, on their mode of displacement (migrating herds or dispersing individuals), or the season in which the movements take place (cavity openings hidden by snow). Although no quantitative data are available, we consider that the species present in the cavities are not the result of anthropic choice and, therefore, provide information about the species present in the environment.

Unlike some older sites (Brugal and Jaubert 1991), the carcasses in these natural traps show no evidence of anthropic intervention. Nonetheless, some tools such as backed bladelets or reindeer antler points are occasionally found. There is no archaeological site in the vicinity that could explain the presence of these objects in the traps. Consequently these probably belong to projectiles that wounded the animals some time before they fell into the cavity.

In 2000, few natural traps had been dated, and none had more than three date measurements. Faced with this lack of data, an investigation of the Igue du Gral natural trap was started in 2001 (Castel and Coumont 2005; Castel *et al*. 2008). The objective was to record the variability of the late Pleistocene fauna within a clearly established chronological context. During the period from the end of the Glacial Maximum to the start of the Late Glacial, five main assemblages can be distinguished (Table 13.3, Figure 13.4). The deposits show some repetitiveness, with rapid accumulations of sediments alternating with phases of consolidation (Camus in Castel *et al*. 2011) for around 2 m. Twenty-four radiocarbon dates are already available. The paleontological deposits from Igue du Gral cover a period from 10,500 BP to over 45,000 BP, with the excavated paleontological levels covering the period from 10,500 to 28,000 BP. Many of the dates correspond to the Recent Solutrean, Badegoulian and Magdalenian. The dated remains, distributed throughout the sequence, show a progressive increase in age. Consequently, there is reason to believe that the identified formations represent periods of accumulation in the order of millennia. Before the Bölling period reindeer, bison and horse are consistently very well represented. Wolf is abundant in the higher layers at the bottom of the main chamber. Mountain hare (*Lepus timidus*) and Alpine chough (*Pyrrhocorax graculus*) are also very well represented.

Surprisingly, very few ibex and chamois remains were found, even though evidence from archaeological sites shows that these two ungulates seem to have been consumed frequently in the Quercy region during this period (Castel *et al*. 2008). Red deer appears sporadically after 16,000 BP. The same is true for Saïga antelope. This is an animal of the plains (Delpech 1989) and, therefore, it is not surprising that the remains of only one individual have been found at Igue du Gral.

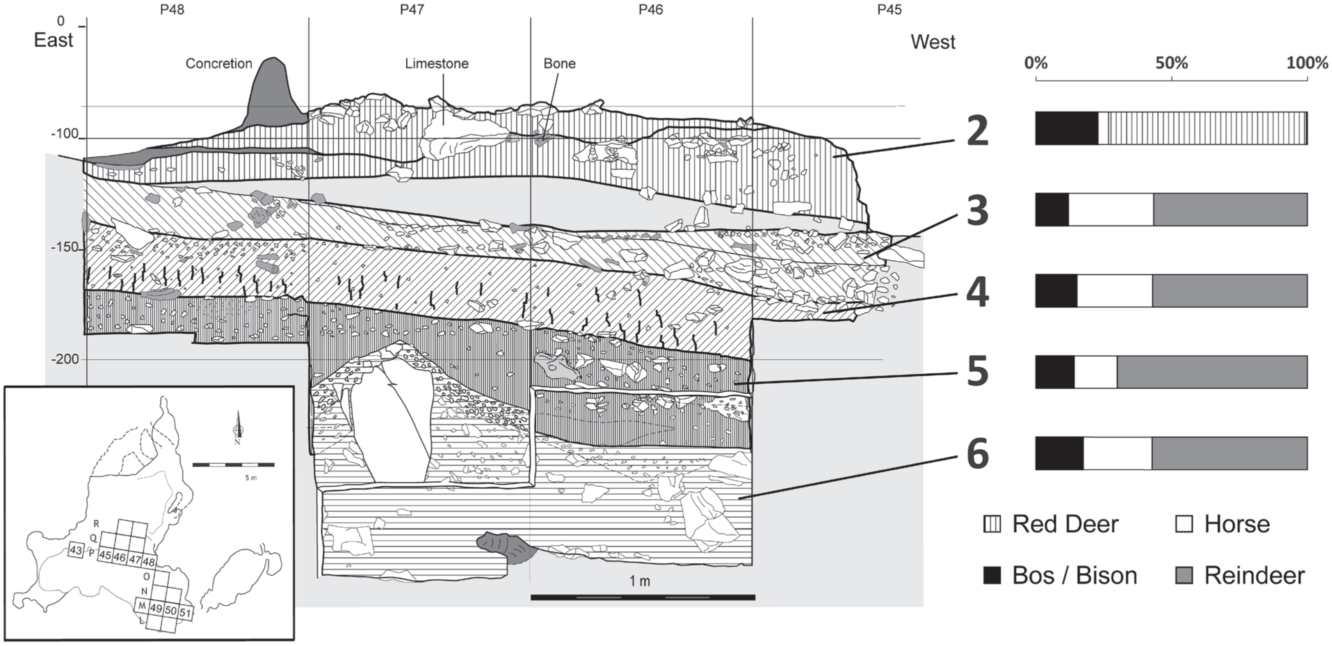

Figure 13.4. Igue du Gral (Sauliac-sur-Célé, Lot, France). Simplified stratigraphy and frequency of main ungulates.

Alongside the excavation at Igue du Gral, several other natural traps in Quercy have been the subject of paleontological investigation and dating. The number of known contemporary sites from the late Upper Palaeolithic has thereby been increased. In addition, regional analysis has shown that the large size of wolves (Boudadi-Maligne 2011) and the small size of horses (*e.g.* Guadelli 1987) are characteristic of the Final Pleistocene in south-west France. The disappearance of hyena and cave bear is now generally considered to have happened before the Last Glacial Maximum (Pacher and Stuart 2009; Discamps 2012); this allows the exclusion of certain undated sites (even though part of their deposits may be contemporary with the end of the Pleistocene).

These studies have allowed us to build up a body of sites covering the whole of Quercy (Figure 13.5). Most of them show a high proportion of reindeer, horse and bison. Those which do not include one of these species are usually small assemblages that require revision. At the regional scale our analysis confirms that reindeer, horse and bison are always abundant during the Recent Solutrean and the Badegoulian.

The other ungulates previously mentioned are sporadically present, but further dates are needed for higher precision. Leporids and birds are present in some assemblages, but absent in all of those where material has been collected by speleologists without archaeological control. The combination of all the paleontological information allows us to reconstruct some aspects of the faunal environments. Ungulates seem to have been present in large numbers throughout this period (see also Brugal *et al*. in press). Mammoth is very rare in the Quercy traps and no remains have been dated (Mancel 2006). The same is true for rhinoceros and megaloceros, and it is, therefore, difficult to know whether they were present during the whole period.

Seasonality indices are currently limited to Igue du Gral (Castel *et al*. 2008) and further analysis is needed. Nonetheless, a few bison and horse foetuses (end of winter to mid spring) have been identified. The teeth of young reindeer also demonstrate a year-round presence, with a relative scarcity in summer. The frontal bones of reindeer skulls mostly relate to the winter season. Our regional scale of analysis shows that reindeer seem to have been present in Quercy for most of the year, although this may have been part of migratory movements between areas that changed over time.

At present, no natural traps for the period studied have been examined in Périgord. Several natural traps have been excavated in Charente (Tournepiche 2006), but we do not yet have enough quantitative data for these deposits to make comparisons.

Towards a new understanding of hunting strategies

Using these results, we can make comparisons with occupied archaeological sites in Quercy (see Table 13.5). The relative abundances in archaeological sites

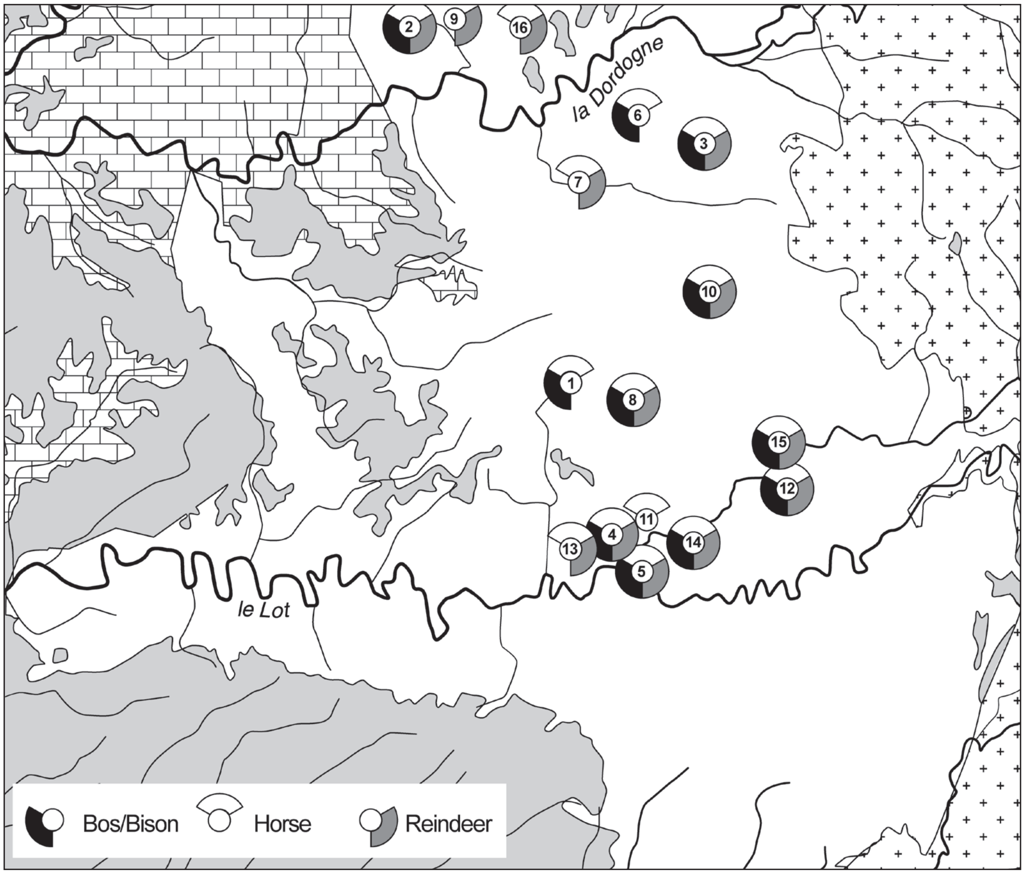

Figure 13.5. Presence of Bovines (Bison or Aurochs), Horse, and Reindeer in natural-traps in the Quercy region. The names of the sites are indicated in Table 13.4.

seem to be the result of human choices and strategies. The rarity of bison and horse hunting in the valleys of Quercy appears to reflect the decisions of the groups inhabiting the sites rather than any scarcity, seasonal or total absence of these species. Environmental factors cannot be excluded, but the available data suggests that these have less weight than was previously thought.

In the absence of comparative data it is difficult to discuss these choices in the northern part of the study region. In Charente, even though the number of horse and bovines hunted was limited, these species provided enough consumable resources (meat and marrow) to play an important part in human subsistence. The fact that the prey spectra included a larger number of species means that comparative data are less important for reconstituting the ungulate paleoenvironment. Périgord, situated between Query and Charente, both of which are rich in taxa, also seems likely to have had a rich and diverse biomass. Thus, there is a body of evidence to indicate that ungulates were widely available in the eastern edge of Aquitaine during the Last Glacial Maximum. To gain a better understanding of the choices made, it would be useful to discover from natural trap excavations whether the species generally missing from the prey spectrum (saiga antelope, red deer) were at least seasonally present in the south of the Dordogne.

The way in which secondary prey species were integrated into the diet in the Recent Solutrean and Badegoulian is a reflection of choice. Large ungulates were preferred in the north, and rupicolous ungulates in Quercy. This distinction is clear for the Recent Solutrean. There are fewer Badegoulian sites, and these are less evenly distributed on the north-west /south-east axis. Those furthest east are located where the relief is most marked. It is reasonable to assume that the steepness of terrain near occupation sites constrained the choice of complementary guilds that were utilised.

Rupicolous ungulates were infrequent or absent in the Agenais hills and probably in the middle of the calcareous plateaus (as shown by the Pégourié fauna). This may have driven the hunting of large ungulates. However, these large ungulates were present throughout the area and the absence of hunting near the Quercy

	Number on Figure 13.5	**Site**	**Commune**	**Faunal study**	**Abundance**	**Age (dates BP)**	***Bovinae (Bos or Bison)***	***Equus caballus***	***Cervus elaphus***	***Rangifer tarandus***	**% *Cervus/Rangifer+Cervus***	***Capra ibex***	***Proboscidian***	**Carnivores**	**Other taxa and remarks**
Ante Pleniglacial	1	Perte de Bramarie	Labastide-Murat	Philippe *et al.* 1980	1	31520 +1970/-1580	x						x		
	2	Siréjol	Gignac	Philippe *et al.* 1980	3	29100 and 31300 (3 dates)	x	x	x	x	50			Various carnivores	
	3	Cave aux Endives	Loubressac	Castel in Coumont *et al.* 2009	3	26460 ± 320	x	x	x	x	R>C			*Panthera spelaea*	
	4	Pech Merle	Cabrerets	Fontana *et al.* 2006	3	26690-36230 (3 dates)	x	x	x	x	R>C	x		*C. crocuta, Ursus spel.*	
Pleni-Lateglacial	5	Gral (level 2)	Sauliac-sur-Célé	Castel *et al.* 2008	3	10500 (3 dates)	x		x		100				Likely *Aurochs*
	5	Gral (other levels)	Sauliac-sur-Célé	Castel *et al.* 2008 and unpublished	3	13360 to 20040 (15 dates)	x	x	x	x	5	x	x	Various carnivores	*Chamois, Saiga*
	6	Barrières	Miers	Philippe *et al.* 1980	2	19940 ± 800	x	x							*B. schoetensacki*; mixed with Holocene ?
	7	Mude		Philippe *et al.* 1980	1	16640 ± 440		x		x					
	8	Lespinasse	Quissac	Philippe *et al.* 1980	2	14480 ± 400	x	x		x				*G. gulo*	
	9	Ajasse	Gignac	Philippe *et al.* 1980	1	16210 +1280/-1510				x					
	10	Pras de Marrou	Durbans	Castel *et al.* 2012	3	14000 to 10500 (3 dates)	x	x		x				*C. lupus,* *U. spelaeus*	*E. caballus,* *E. hydruntinus*
Undated sites showing no argument against an attribution to either Pleniglacial or Lateglacial.	11	Olivier	Cabrerets	Castel in Coumont *et al.* 2009	2			x				x			
	12	Lespine	Marcilhac	Coumont *et al.* 2009	2		x	x		x		x			
	13	Cloup Barrat (Igue)	Cabrerets	Castel unpublished	2			x		x					
	14	Patte d'Oie	Sauliac-sur-Célé	Coumont and Castel unpublished	3		x	x	x	x	C>R				
	15	Brengues	Brengues	Philippe *et al.* 1980	3		x	x	x	x					*Bison schoetensacki,* *E. hydruntinus*
	16	Faurel	Cuzance	Coumont *et al.* 2009	3										

*Table 13.4. Faunal traps of the central Quercy region with Upper Pleistocene fauna, containing rich remains of large and medium size ungulates (*i.e.* reindeer). Abundance of ungulates: 1. less than 20 remains; 2. between 20 and 100; 3. more than 100 remains. According to the fact that some dating results were obtained more than three decades ago, we decided not to calibrate them.*

		Recent Solutrean	**Badegoulian**
	Chronological limits (ky cal BP)	*24500–23000*	*23500–21000*
Hunting strategies	Ongulates	Reindeer, Horse and Bison abundants	
		Ibex and Chamois present on relief	
	Other potential preys	Canids, Leporids and Birds	
	Main prey	Reindeer (over 70%)	
	Geographical heterogeneity	North-south gradation	No gradation
	Other prey	No birds, carnivores or small prey	
	Mass kill	No	No
Bone tool production	Length of bone-working production sequence	Long sequence for projectile	Long sequence for projectile
		Long or short sequence for tools	Frequently short sequence for tools
	Morpho-functional variability	High	Low
Body ornaments	Body ornament technics	Perforated or notched ornaments	Body ornaments with perforations
	Morphological variability	Medium	Low
Brief information concerning lithic economy	Raw material procurment	High planification	High Flexibility
		Long distances frequent, generally linked to hunting equipment (economic strategies, exchange networks?)	Significant use of local raw materials and tool-kits transported long distances (tools and thick flakes as raw material reserves) equally linked to domestic and hunting equipment
	Site 'typology'	Contrasted site 'typology'	Slightly differentiated type-sites

Table 13.5. Elements of comparison between Recent Solutrean and Badegoulian in Eastern Aquitaine.

valleys represents a choice. To suggest that it is due to the relief seems improbable; Quercy is characterised by valleys, but the altitude differences are never more than 200m and there are numerous crossing places.

In the Recent Solutrean, if the observed distribution is representative of the habitation choices within the study region, we can consider the spatial divide of territories along the eastern edge of the Aquitaine catchment to be intentional. This is not the case for the Badegoulian. The strategies adopted show little or no evidence of paleoenvironmental or paleoclimatic constraint, and an explanation of the differences observed must be sought in other parameters relating to the economy, or the structure of human groups. It should be observable in the bone and lithic industries or the production of symbolic artefacts, and we have therefore examined these data.

Discussion: subsistence strategies in relation to technical and symbolic production

The choices made by hunters during the Last Glacial Maximum may be understood by determining whether the differences observed in prey spectra can be explained by a changing environment, or a different relationship with the environmental fauna. Investigation of faunal traps allows us to reconstruct the animal environment of Quercy, and so reconsider hunting strategies used on the eastern border of the Aquitaine basin during the Recent Solutrean and Badegoulian. Reindeer are generally the preferred prey of these populations. During the Recent Solutrean bovines and horse play a secondary role in the north, and ibex and chamois in the south-east. This apparent northwest/southeast divide of territories is also seen in the circulation of lithic raw materials and ornaments (Geneste *et al*. 2008). In the Badegoulian the situation is less clear. The importance of secondary prey still seems to be spatially determined, but relief plays a more important role. This fits in with the search for other habitats to exploit, notably the rolling plains of the Agenais.

The changes in supplementary prey guilds and use of territory reveal the choices and, thus, the economic organisation of the populations inhabiting eastern Aquitaine. The relative abundance of ungulates may be explained by the different relationships between hunters and their potential prey. Bison and ibex do not provide the same amount of food and are hunted in very different ways. In summary, bison provide a lot of meat but require a lot of hunters to procure. They could have been hunted at river passes, but one should note that this is not the case in the Quercy region, where bison are abundant but not hunted (Pégourié is an exception but localised in the middle of the plateau). Conversely, ibex may be easier to hunt in a very local, predictable habitat (Quercy cliffs along the rivers) and provides a small amount of food that is potentially adequate for small groups. In paleoethnological terms, this classification of resources may be related to the size of such groups and their land use, or modes of travel. These hypotheses, compatible with Optimal Foraging Theory (*e.g.* contributions in Winterhalder and Smith 1981) may lead us to interpret the increase of ibex hunting as a marker of smaller groups for which stable resources, such as ibex, complete reindeer acquisition.

The exploitation methods and alimentary choices used upon ungulate carcasses may reflect these different kinds of organisation. Unfortunately, as we have seen, precise data are too scarce. To stay within the context for which archaeological data are more easily accessible, these data must be compared with the analysis of bone and lithic industries. Analysis of the lithic technology the Aquitaine Palaeolithic has shown that the Recent Solutrean presents a hierarchical technical system based on a high degree of planning and spatio-temporal division of activities. It is notably characterised by contrasting site typologies (Renard 2008). Conversely, the Badegoulian shows a flexible and adaptable technical system, where sites are only slightly differentiated. This can be interpreted as indicating forager-type mobility (Ducasse 2012).

In these preliminary results we demonstrate that all of these different economic aspects are interrelated. Further research is now required to discover exactly how and why this is the case. The comparison of zooarchaeological data with those of lithic and bone industries, together with a better understanding of regional symbolic artefacts, opens a new dimension that we intend to approach through an interdisciplinary understanding of the economy at this time. Consequently, it should be possible to bring to light internal changes within hunter-gatherer groups that may not be linked to replacement or the integration of different populations, as at the beginning of the Upper Palaeolithic, or to changes in climate, such as those indicated at the end of this period.

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We extend our thanks to Christophe Griggo, Stéphane Madelaine and Eugène Morin, authors of unpublished zooarcheological studies. The study of the natural traps in Quercy was started by J.-P. Brugal and continued by M.-P. Coumont as part of a collective research program, which is the source for the dates of some of the palaeontological sites. Our research in Quercy was financed by the French Ministry of Culture and the Conseil Général of the Department of Lot. The figures were formatted by Florence Marteau (Muséum de Genève). The English translation was done by Anita and John Hollier.

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14. Locating Potential Mesolithic Fish Sites in Britain using Predictive Modelling: Applying the 'fishing site model' to British conditions

Kris Hall

Introduction

In the United Kingdom, only a very limited amount of work has been undertaken on submerged, sub-littoral Mesolithic archaeological sites. The work at Bouldnor Cliff in the Solent is currently the only example of a concerted archaeological investigation of a permanently submerged Mesolithic site in the UK (Momber *et al*. 2011). Hence, little is known or understood about how Mesolithic people interacted with the coastal zone and the potential for the preservation of archaeological remains. This is in contrast with an extensive record in areas such as the Baltic region (*e.g.* Andersen 1985; Karsten and Knarrström 2003; Pedersen 1997, 142, Figure 23; Skaarup and Grøn 2004). While large-scale fishing in the Mesolithic has been proven by shell and bone assemblages, as well as structural remains of traps in southern Scandinavia and elsewhere in northern Europe (*e.g.* Langouët and Daire 2009, 144; Lozovski 1999; Verhart 1995, 299–300), the evidence within Britain remains largely absent. This paper argues that fish traps were almost certainly used and that marine exploitation is likely to have been as important in the British Mesolithic as on the continent. Recent Irish examples of Mesolithic fish weirs (McQuade and O'Donnell 2007) underline how unlikely it is that this technology somehow 'jumped' Britain; we have simply not looked properly or in the right places. Today the traps and associated sites would be mostly underwater, where little research has been done, and there is a need to develop a methodology for systematically locating submerged Mesolithic sites. For this reason, I have employed Anders Fischer's 'fishing site model' (Fischer 1993, 1997, 2007), a highly effective topographical predictive model that seeks to locate coastal Mesolithic sites based on topography and bathymetry. The main objective is to suggest ways of adapting and applying this model to British conditions, whilst formulating an approach to look for underwater coastal Mesolithic fishing sites that does not require a high level of expertise nor great expense, something that was central to Fischer's original work.

Background and context to fishing in the Mesolithic

It is clear from the archaeological record that fishing played a major part in the lives of Mesolithic peoples. In many parts of northern Europe there is now an appreciation of the importance of coastal sites and their role in larger settlement networks and, more recently, of the permanence that many of these sites display (*e.g.* Petersen 1984; Schilling 1997). In particular, cemeteries from the later Mesolithic, such as Vedbæk (Albrethsen and Petersen 1976), seem to indicate increased sedentism and less mobile settlement structures, something further supported by evidence for traits that would have allowed these communities to live in coastal locations for most of, if not all, the year round. This is documented by direct and indirect evidence for large-scale marine exploitation in the form of skeletal remains and tools used to catch and collect fish and shellfish (*e.g.* Andersen 2007; Rowley-Conwy 1984). Perhaps the most striking examples of this come from southern Scandinavia where, in addition to large shell middens containing fish remains, occupation sites have been found in association with large fish traps, such as at Tybrind Vig (Andersen 1985) and Tågerup (Karsten and Knarrström 2003). The northwest European Mesolithic saw an increasingly productive coastal zone and fishing using stationary traps would have been a method of catching much more with a minimal amount of 'continued' effort, allowing for more densely populated areas (*e.g.* Pedersen 1997a). It could be argued that stationary fish traps, and the coastal zone in general, are symptomatic of an 'optimal foraging' strategy as defined by Perlman (1980). Fish weirs have, therefore, been suggested to indicate a highly evolved complex social system with ideas of territoriality and a close connection to the landscapes in which they lived. This is far from the classic image of Mesolithic hunter-gatherers as 'primitive' people eking out a living on a day-to-day basis (Pedersen 1997a, 143).

'Fish sites', in the context of this work, relate to places where techniques using permanent or semi-permanent wood or stone structures for catching fish, commonly known as 'weirs', could have been used. Brinkhuizen (1983, 15) describes a 'weir' as: "*…a kind of barrier or obstruction that leads fish to a spot where they can be easily caught and taken out of the water*". This type of trap has been used in many parts of the world for millennia, and is seen as early as the Mesolithic, with examples from areas such as the Danish Baltic (Fischer 2007), and in the Neolithic in Britain (*e.g.* Hartlepool Bay dated to 3932–3665 cal. BC; Buglass 1994; Waughman 2005). The obvious longevity and ubiquitous nature of the practice (for example, Pedersen (1997b) mentions how fish traps have hardly changed over the course of 7,000 years in Denmark) suggests that stationary fishing is likely to have preceded the Neolithic in Britain. Historical and ethnographic examples also exist in places like the Severn Estuary, where this technique continues to be practiced (Bell *et al*. 2000, 34, 62; Salisbury 1991), and in Britain and Denmark this type of fishing was common practice up until the mid-19th century, after which weirs were banned in favour of alternative systems using nets (Aston 1988; Hall and Clarke 2000; Jenkins 1974, 5–6; O'Sullivan 2004, 452–454; Strachan 1998).

The evidence from the southern Scandinavian and Irish Mesolithic indicates that fairly simple and fragile wooden weirs were in common use along sheltered coastlines and on inland waterways, either where topography or currents would lead fish into the traps, or where the tidal conditions were such that fish would be caught by the fences on the falling tide (Brinkhuizen 1983, 15–17; Von Brandt 2005, 199–214). Examples of stone traps from Australia (McNiven *et al*. 2012) and in the British Isles (Bannerman and Jones 1999) also potentially date to early prehistory. These could either be made entirely of stone or a combination of stone and wood/wattle/netting, functioning as standard weirs, or as tidal dams or pools, similar to some of the examples from Australia, Anglesey, and Carmarthen (Von Brandt 2005, 199–214; Bannerman and C. Jones 1999; Turner 2002, 100). Due to the more exposed nature of many of Britain's coastlines and the abundant availability of stone, it is likely that this material could have been used in early prehistory to produce structures similar to modern examples from Minehead and Swansea Bay in the Bristol Channel, at least as supports to the weir and/or to prevent scouring (Bannerman and Jones 1999, 72).

While the evidence for large-scale Mesolithic fishing from Britain itself continues to elude us, examples in neighbouring European countries, where conditions would have been similar (*e.g.* Dupont *et al*. 2009, 101–102), pose the question 'why would Britain be any different?' The recent discovery of Late Mesolithic fish traps in the Liffey Estuary in Dublin (McQuade and O'Donnell 2007), which bear remarkable similarities to examples from other parts of Northwest Europe, particularly Denmark (*e.g.* Fischer 2007; Fischer 1993) and Sweden (*e.g.* Regnell 2011, 3), adds to this debate. This only strengthens the argument that, even though no clear evidence of Mesolithic weirs has been found in Britain, such structures must have been known about, and almost certainly used, in at least some British coastal settings (English Heritage 2011, 3). They were likely to have been located on or near areas that were also attractive to later settlements and harbours (Bathgate 1949, 98–99; McQuade and O'Donnell 2007, 569), something which should help guide cultural resource management schemes and be considered when looking for these types of sites.

As Fischer (2007) proposed, one reason for the apparent lack of many submerged sites in Britain and elsewhere probably stems not so much from an actual lack of prehistoric activity (which is, of course, evidenced inland and at a growing number of coastal locations) or physical remains, but rather from a poor record of investigation and investment. He argues that this is mainly due to a perception that survival, identification, and accessibility of potential sites that are now underwater makes them unattractive, especially in the light of good terrestrial (inland) sites (Bailey and Flemming 2008, 2160; Fischer 2007, 56). Problems with poor preservation, retrieval, and identification of midden deposits is possibly another reason the record is so limited, giving a potentially highly distorted image of the level of marine exploitation, with fish bones often only making up a tiny fraction of the entire assemblage at coastal sites, such as Culverwell (Palmer 1999) and Low Hauxley (Waddington 2010). Emphasis should, therefore, be placed on fine-sieving coastal Mesolithic sites. In Denmark, much evidence comes from shell middens in the north of the country, now above sea level, while in most of southern Britain the opposite applies. All or most coastal middens would, thus, be submerged, while in the northeast coastal erosion and a general lack of targeted retrieval of fish bone could have played a large role in giving the impression that fishing was not particularly important.

The reason (Baltic) Denmark has been the scene of so much underwater investigation into prehistoric activity comes down to several favourable factors: calmer seas and moderate tidal ranges; areas of little post-glacial tilting/dipping action; a generally good environment for preservation; and, importantly, the investment in time and resources for developing working methodologies and investigations of sites, which has not generally been the case in the UK. In Denmark this means that remains are often found at shallow depths, uncovered by gentle wave and tidal action or concealed under a thin layer of sediment (Fischer 1993), often with astonishing preservation, such as at Tybrind Vig (Andersen 1985). While there are questions in the context of Britain in terms of preservation, identification, and recovery of coastal fish traps, there can be little doubt that Mesolithic people would have been more than capable of constructing such structures. Fish weirs and traps have been found and are known all around the coasts of Britain from the early Neolithic onwards, even in places which may initially appear hostile to such structures, such as beside fast-moving currents and exposed areas, for example at Hartlepool (Buglass 1994; Waughman 2005), and can also be seen in places such as Brittany with similar exposed and tidal conditions (Langouët and Daire 2009).

While sites with excellent preservation were discovered using the fishing site model, initial discovery of Mesolithic activity in Denmark was generally through the recovery of lithics lying exposed on the sea bed, or through small-scale test-pitting (Fischer 1997). Such scatters are useful and have been found in places such as at Wootton Quarr (English Heritage 1996) and Low Hauxley (Waddington 2010), but as long as we are only finding them in contexts with no evidence of intensive coastal exploitation, all they tell us is that Mesolithic people were present in the coastal zone. At Wootton Quarr (Tomalin 2000; English Heritage 1996), the possible remains of early Neolithic and later stationary fish traps close to probable Mesolithic flint scatters are highly suggestive that, if we were to look more closely at greater depths, similar structures could be found dating to the earlier period, albeit probably covered by more sedimentary deposits. It is encouraging that there is so much archaeological activity from later periods (and even earlier in the case of Bouldnor Cliff), particularly in the Solent (Momber *et al*. 2011) and Bristol Channel (Bell *et al*. 2000), suggesting that these environments were of major importance to coastal populations for millennia, and that these remains have been found to survive well.

The 'fishing site model'

Fischer (2007) devised a model for identifying likely sites of prehistoric significance in submerged coastal locations based on bathymetry, using simple navigational charts and local knowledge of prime, modern-day fishing sites. The basis for his theory was derived from personal experience – find-spots of prehistoric activity happened to correspond well with areas of good fishing in the present day. The premise of his model was:

> …based on the assumption that the people of that age lived in the immediate vicinity of the best locations for coastal fishing with stationary structures built of stakes and branches.
>
> (1997, 63)

And that:

> In many cases a simple way of getting started in searching for these sites could be through a locally adjusted approach, based on…: predictive models of site topography; depth contour maps of the sea floor (at a scale of 1:40,000, or more detailed); a small boat with standard echo sounding equipment; divers with some degree of archaeological field experience.
>
> (2007, 58)

Simply by looking at navigational charts with rough depth outlines (or isobaths) of the underwater topography, together with data on local sea-level changes, one can, according to this model, estimate where fish sites were likely to have been located in prehistory. In Fischer's case, he achieved an accuracy of more than 75% in his survey in the Småland Bight in Denmark, finding mostly Kongemose sites at 3–5 m below sea level (Fischer 1993, 70, 74; Fischer 2007, 56). Perhaps the most significant contribution that his work has had to maritime archaeology in Denmark is an increased awareness of the importance of the submerged archaeological environment and the need for creating safeguards to protect this very useful, but also very fragile resource. Tellingly, in Britain, where much less research has been carried out in coastal locations using this methodology, only a very small number of areas of Mesolithic activity have been identified. Most notable is the work carried out in the Solent (Momber 2000, 2004), the Severn Estuary (Bell *et al*. 2000), and the Western Isles of Scotland (Gregory *et al*. 2005). By inferring from the Danish evidence, however, Fischer suggests it is highly likely that weir fishing and, by extension, coastal settlements can be found in British waters through the use of predictive models adapted to localised conditions (Fischer 2004).

The areas that the model regards as suitable for fishing can be seen in Figure 14.1 (Fischer 1997, 66). It indicates that sites were particularly likely to be located in estuarine areas, on narrow channels where fish are funnelled in, or on land that juts out into fairly shallow waters. Fieldwork has proven that, logically, these rather fragile structures were mostly placed in relatively sheltered areas. In order to locate these,

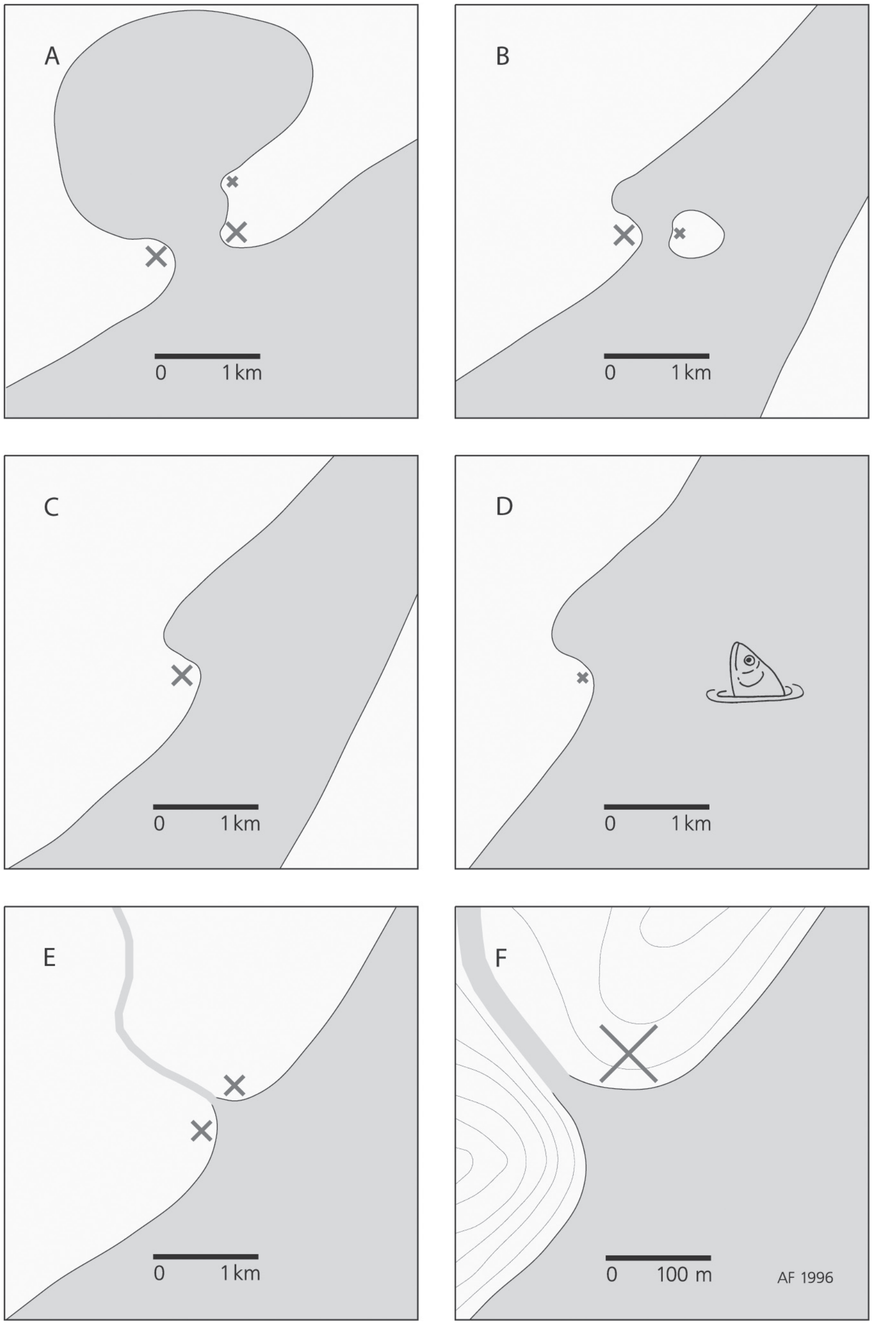

Figure 14.1. The different categories of sites in Fischer's model: A. along a narrow strait between large water areas and with a large hinterland on both sides of the channel; B. along a narrow strait between a small island and a more substantial landmass; C and D. near the point of a projecting headland; E and F. by the mouth of a major river on the shore of the sea or a fjord (Fischer 1997b, 66). X demarcates the potential for fish sites.

most of which have been subject to sea level change to varying degrees, the model uses commercially available navigational charts using the depth contours as proxies for past coastlines (*ibid*., 67), marking spots in terms of three categories for the likelihood of Mesolithic activity: very suitable, fairly suitable, and partly suitable. As mentioned above this simple approach has proven highly successful and in the Storebælt they concluded, on the basis of extensive fieldwork, that Mesolithic activity sites were concentrated around the locations that the model had predicted to be good fishing sites (*ibid*., 70). It was also shown to work down to at least 8–9 metres with a clear chronological correlation between depth of sites and their age (*ibid*., 72), suggesting that even earlier archaeology may be hidden at depths down to hundreds of metres below sea level (*e.g.* Grøn and Mortensen 2011), something which is promising for British waters.

The model has been shown to work, though not always, nor in all conditions. Lindholm I, a Mesolithic fishing and occupation site in the Storebælt channel, did not initially look promising based on a chart survey, but careful environmental modelling of the geology and sedimentation revealed an earlier topography that was indeed suitable for fishing (Fischer 1997, 70). It was pointed out that a proper understanding of the geomorphological processes in an area is necessary to identify large numbers of underwater sites (*ibid.*, 72), and the potential that sites such as Lindholm hold, *i.e.* sedimentary deposits, may obscure the Mesolithic evidence, but will also protect any valuable archaeology beneath.

Research methodology for proposed model adapted to British conditions

The Danish model is unlikely to work without modification in a British context, especially when the factors that set these two areas apart are considered, *i.e.* increased erosion, stronger tides, more powerful storms and winds, and less emphasis on underwater work (*i.e.* no control samples). As discussed above, the Baltic region of Denmark is composed of a relatively calm and moderate archipelago environment ideally suited for the preservation and discovery of Mesolithic archaeology. In Britain there has been more emphasis on rivers and estuaries for stationary fish traps (*e.g.* Salisbury 1991), because of the stronger tides, greater presence and larger size of rivers, and the relative absence of calm areas, such as those found in the Danish Baltic. Particularly on exposed coastlines, investigation should be focused on sheltered areas, for example bays and, especially, estuarine locations.

The most important factor when approaching this topic is an understanding of how the landscape and coastline would have appeared in the Mesolithic, where archaeological sites were located within it, and how these sites formed. The possibility that estuarine and riverine areas in particular could have been locations where large scale fishing was practiced is reinforced by the fact that they are incredibly productive environments. They not only provide access to fish, but also to birds and mammals. In Denmark, high numbers of bones in midden deposits, for example from swans, have been used to suggest a reliance on these as a valuable resource at times of the year when other food sources were scarce (Rowley-Conwy 1984).

The key to creating meaningful reconstructions of past environments for use in locational modelling is to understand the geomorphological processes that particular areas have undergone. This requires the expertise of a range of specialists from geoarchaeologists to sedimentologists and can, as a result, be a time-consuming and expensive, but ultimately rewarding undertaking, if the funds are available. Coastal geomorphology has had a major impact on parts of the British coastline, such as the northeast of England, where coastal erosion has destroyed or obscured much Mesolithic archaeology (*e.g.* Waddington 2010), or the dynamic underwater environments found in for example the Solent (Tomalin *et al*. 2011). This is likely to have played a major part in the types of fishing strategy used at different sites, but perhaps less so on, or near, estuaries, such as the Liffey Estuary.

Environmental reconstructions of past landscapes (or 'coastscapes'), also need to account for the resources available and the conditions for fishing. In order for passive fishing to work, the supply of fish must be reliable and, if not all-year round, then on a seasonal basis. Evidence for the types, distributions, and seasonality of fish species in prehistoric locations can only come from fish remains or, sometimes, can be tentatively implied from the remains of specialised types of traps that target specific species. This underlines the need for proper and appropriate sampling. Factors such as these help determine the type of marine exploitation employed in a particular place, which in turn can guide the archaeologist towards an understanding of what to look for, for example whether wood or stone built weirs would have been the most likely construction method used.

The location of recorded Mesolithic inland and coastal settlements can be used to suggest the level of Mesolithic activity in an area, for example, high levels of activity are indicative of large populations and a greater need for large-scale food procurement strategies. They can also indicate likely periods of elevated activity, which can be used to modify eustatic and isostatic reconstructive models based on date, producing a more accurate picture of where to look. In cases where submerged sites are known, such as Bouldnor Cliff, the depth of these can also be used to adjust sea level reconstructions, as proven by Fischer in Denmark (1993, 1997, 66–72). Proximity to sites exhibiting year-round occupation is of particular interest as it can indicate that they (or sites in the same area) might have developed a reliance on intensive hunting and gathering that may well have included fishing, among other things. Potential evidence from midden deposits that suggests probable fishing activity should also be used to focus on certain locations. An important part of Fischer's fish site model was based on the information he gained, particularly from local fishermen, about general weather and tidal conditions and areas of prime fishing, something which should be standard procedure when using this model, together with historical and ethnographic examples if in an area of weir fishing.

Another important question one needs to ask is whether anthropogenic activities are likely to have destroyed any potential archaeology in the area being studied, something which affects busy areas, such as the Solent, and how to incorporate this into considerations about likely locations, and whether they will interfere with archaeological work. Many sites (*e.g.* Bouldnor Cliff) have been found because of fishing activities, while much of the 'control' data used by Fischer regarding types and dates of sites, and at which depth these were found, came from local dredgers recovering clues in their spoil (Fischer 1993). The potential for dredging and fishing activities to locate new sites is significant and underlines the need to create liaison strategies with these groups (Buglass 1994).

While later projects that incorporate the fishing site model have used more advanced equipment, Fischer's original approach is one that is very attractive because, instead of relying heavily on highly trained experts and expensive equipment, he worked with amateur divers who had an interest in archaeology, as well as archaeologists, using nothing but a small fishing boat equipped with sonar. For initial work in the UK this may be an approach worth considering. The man-power and equipment available is a major consideration and should be factored in from the start, together with the problems of working in coastal locations, whether above or below the sea. As Bell *et al*. (2000, 10) and Momber (2011) have indicated, it is important to appreciate the difficulties and dangers involved with working in coastal locations, risking exposure to large tidal ranges that can easily reach five or more metres in one day, between Mean Low Water (MLW) and Mean High Water (MHW) in some areas. This is especially relevant when working in the intertidal zone; not a serious problem in the Baltic, although Fischer relates working in strong currents, murky water, sediment build-up and more in the Storebælt (1997, 68).

To aid the discovery of fishing sites in the coastal zone, various surveying methods are available. Aerial photography has been used to good effect in the intertidal zones of the Bristol Channel and Brittany (Crowther and Dickson 2008; Daire 2009), although it was noted that many weirs were missed and that dating, of course, is virtually impossible. Aerial photography and similar remote surveying methods are only partly successful, even for later weirs, and are, according to Crowther and Dickson (2008), unlikely to work for Mesolithic archaeology at all. Marine geophysical and geotechnical surveying methods are also unlikely to work in some situations, although surveys of the sea bed using seismology have proved useful in deeper areas of the Solent and may be used to investigate for 'humps' that could represent sediment build-up against weirs (*e.g.* Gaffney *et al*. 2009, 67–104).

A more realistic (and, again, cost-effective) approach to surveying possible sites would be to follow Fischer's lead. Divers would scour each site for artefacts and, if need be, open up small test pits. In the UK, test-pitting to get through sedimentary layers is probably necessary in most places, but could also be done through large-scale testing, such as at Lindholm I, where industrial earth-moving equipment was used (Dencker 1997, 88). Of course, cost is ultimately the deciding factor.

Summarising the model looks something akin to the following:

1. *Data acquisition*:
   - The coastal bathymetry and topography of the study area.
   - Holocene sea level change reconstructions for the study area (sea level curves).
   - The locations of known sites of Mesolithic date in the area.
   - Any proxy evidence, such as stable isotope and fish bone assemblages that is available for the area.
   - The general surrounding geology.
   - Modern tidal and weather information as indicators of past conditions and of the working conditions.
   - The types of fish and their seasonal patterns today (and what that indicates about fish trap types possibly used).
   - Local knowledge about prime fishing spots.
   - Ethnographic and historical examples in the area of stationary fish traps.
   - Access to basic resources such as freshwater and construction materials (*i.e.* together with weather conditions, what kind of structure is likely to have been used?).
   - Destructive anthropogenic activities in the area such as dredging.
2. *Data analysis*:
   - Recreate the past coastlines for *e.g.* the early, middle and late Mesolithic periods using sea level data and charts.
   - Reconstruct recent coastline changes using old maps and assess rates and scale of change.
   - Identify and assess what type of surveying is possible/likely.
   - Assess the likelihood of finding Mesolithic remains including geomorphology and how it may have influenced the preservation and identification of archaeological remains.
3. *Results and interpretation*:
   - Using the above data, mark areas of potential on charts in GIS, based on their potential of being fishing sites and their 'age'.
   - From the above point identify and narrow down the sites or areas that stand out as appearing particularly well-suited.

Example of the model 'in action' – identifying areas of potential

The scope of this project has not allowed for fieldwork to be carried out and the results here are, therefore, merely based on a desk-based process of adapting and 'testing' Fischer's fishing site model to one area of Britain, hopefully providing a suggestive basic framework for working in British conditions.

Carmarthen Bay, Caldey Island

The decision to look at the Carmarthen Bay area came mainly from the fact that large scale charts were readily available at the 1:25000 and 1:75000 scales and because the historical, geological and environmental related factors indicate an area fairly well-suited for the fishing site model. From the maps it is clear that many factors are potentially favourable to coastal fishing: a relatively sheltered bay area, at least three large rivers culminating in an expansive and productive estuarine environment, large tidal ranges added to wide and gradual depth contours down to at least the 30 m contour line, and depth contours that indicate past coastlines with sheltered inlets and a number of small islands. Historical examples of fishing weirs were also located in the bay (Turner 2002) and elsewhere in the Bristol Channel (*e.g.* Smart 2003, 59–62), attesting to the effectiveness and longevity of this method of catching fish, and of the continued rich fishing in the area over millennia. Sites of Mesolithic ages are also found around the edges of the bay and on Caldey Island (Coflein 2013), as well as further into the Bristol Channel at *e.g.* Goldcliff, a site that is suggestive of seasonal eel fishing (Bell *et al*. 2000, 53–54, 62). Large-scale marine exploitation in the early prehistoric is also heavily hinted at by both activity sites and stable isotope analyses on bone from Caldey Island (*e.g.* Schulting and Richards 2002), making this a prime target for investigation.

The proposed middle (20 m contour line), and to an extent early (30 m), Mesolithic coastlines have several headlands and bay-type environments and it might be reasonable to suggest that, as in modern times, the estuarine environment would be where activity was located, although there are no clues from the bathymetry. The proposed late Mesolithic coastline (10 m) is similar but with even more areas where stationary fish traps may have been placed, such as around Caldey Island. Comparisons of coastlines from nineteenth century Ordnance Survey maps with the modern maps show very little change and it is reasonable to suggest the general shape underwater may still be indicative of the Mesolithic coastline, even if considerably eroded or built-up with sediments. The area around Caldey Island, in particular, appears to have had less sediment build-up as well as exhibiting several of the conditions that agree with the model such as the presence of inlets, headlands, and islands. Targeting locations based on bathymetry is therefore potentially easier and more accurate, even if sites here are more likely to have suffered erosion. Figure 14.2 shows the area around Caldey Island in more detail, with the circles indicating areas that have been picked out as being particularly likely locations for future research using Fischer's model.

Conclusions and proposed future work

The methodology suggested in this work has focused on locating potential fishing trap sites. While this is beneficial in itself, it is the human activity that such traps would indicate that is most exciting, and the greatest gain one would get from identifying such structures. Even small-scale fish weirs would have required a massive input of labour for construction and maintenance, implying permanence of settlement and the complex organisational structures needed to build and maintain them.

While the British coast, in general, is unlikely to be as favourable to the preservation and subsequent discovery of Mesolithic activity when compared to the Danish examples, it should not discourage this type of investigation. The problem of erosion can actually be beneficial in some cases, as seen at Bouldnor Cliff, and should be a spur for an increase in archaeological work in the coastal setting. This is already happening to varying degrees across the country. For example, archaeologists are now trying to work with, rather than against, industry (*e.g.* the Aggregrates Levy Sustainability Fund), as well as training and involving a range of individuals, including recreational divers, through organisations such as the Nautical Archaeology Society and projects like the pan-European SPLASHCOS research network (SPLASHCOS 2012).

The approach outlined here is, by its very nature, inductive rather than deductive, with all the inherent limitations this brings. However, even if the sorts of coastal fishing that we see in the Danish Mesolithic were not carried out in Britain and could not, therefore, be used as an indicator of where the remains of occupation might be found, it does not detract from the fact that more work needs to be focused on the submerged prehistoric landscapes of Britain where there is, almost certainly, a 'treasure-trove' of archaeology waiting to be discovered through a systematic and targeted approach. It is suggested that coastal surveys, such as the Rapid Coastal Zone Assessment Surveys, while useful, should also be coupled with a model akin to the one proposed here, in order to target the broader coastal landscape, including underwater, in the immediate

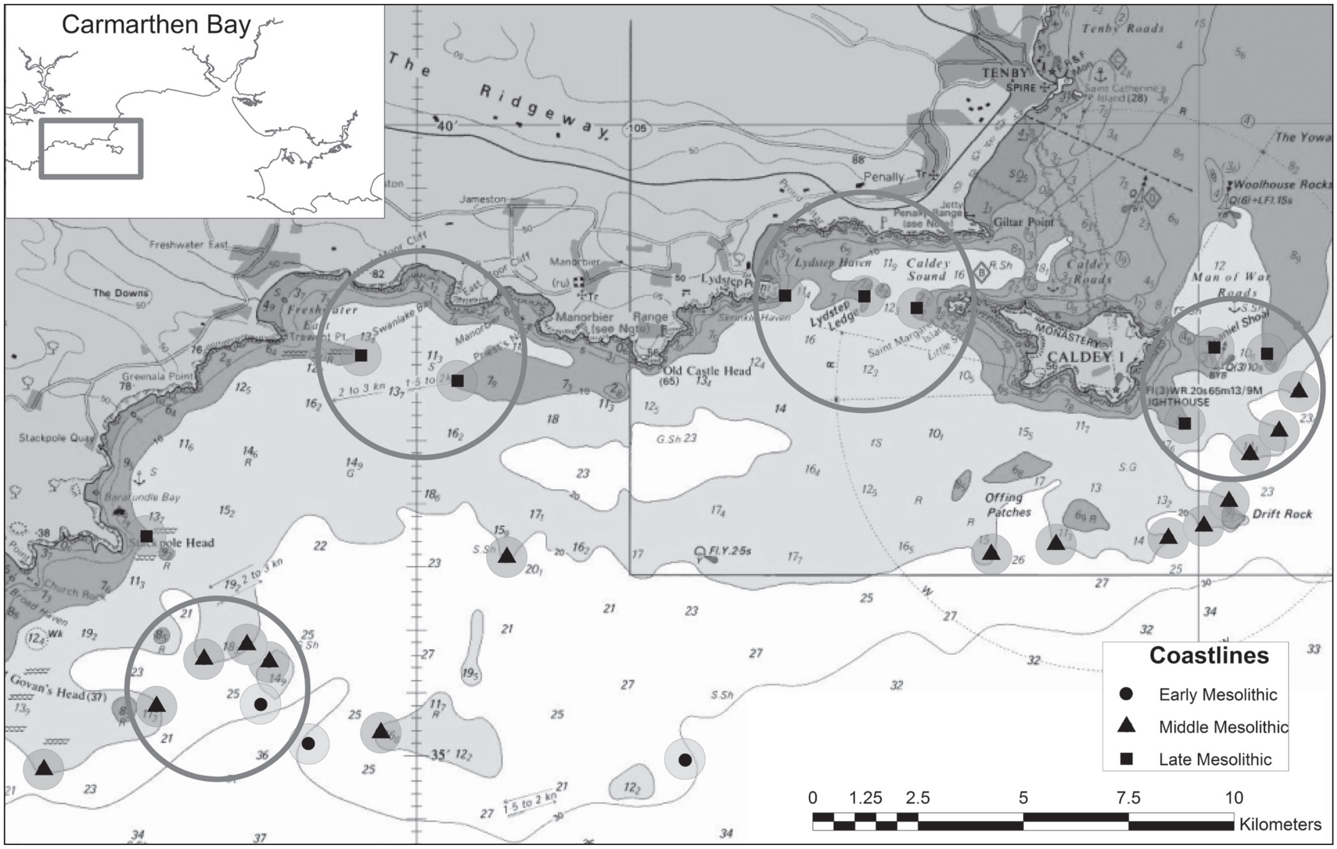

Figure 14.2. Proposed areas with a good likelihood for large-scale fishing in the area around Caldey Island, which has known Mesolithic archaeology, and the probable bay and inlet type environment of the past indicated by the bathymetry (UKHO 2012).

sublittoral environment. We need to appreciate the potential archaeology that lies off the coasts of Britain and beyond, and recognise the need to protect this fast disappearing resource.

The obvious next step would be to take this model and test it in the field to see if it can work in Britain. This paper should be seen as a preliminary review of the available data, suggesting intensification in the study of submerged landscapes around the coasts of Britain, aided by models that help guide and target areas for research. While the model focuses on the Mesolithic, it could easily be adapted for other periods, and such an approach could be particularly interesting in connection with the potential use of stationary fishing structures in the later Palaeolithic, although these are likely at much greater depths than their Mesolithic equivalents (Peter Rowley-Conwy, pers. comm.). Growing datasets, many of which are increasingly being made freely available (including LIDAR, wind and tidal data), and improved techniques in marine geoarchaeology are also factors that are beginning to open up the marine environment to archaeologists over larger areas and in greater detail.

I want to finish by quoting from a piece of Fischer's early work, in which he discusses Danish underwater prehistoric archaeology:

> Regarding Stone Age settlement on the sea floor we hardly know anything. The archives of museums and other institutions contain information on only a few of the many settlements that must be hidden under water. In many areas there is no information at all. Where it does exist, it is often both scanty and inaccurate…
>
> (Fischer 1993, 61)

He could almost have been describing the situation in Britain which today is in a similar position to Denmark in the early nineties in terms of what is known of the submerged prehistoric environment. It underlines the need for concerted programmes of investigation using techniques to help target specific areas as suggested in this paper. The effectiveness of the model presented here has proven itself in Denmark over the last few decades, and shows what might also be achieved in Britain if such an approach were to be adopted.

Acknowledgements

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15. Foragers and Farmers in Mesolithic/Neolithic Europe, 5500–3900 cal. BC: Beyond the anthropological comfort zone

Peter Rowley-Conwy

Introduction

In this contribution I will consider the relationship between Mesolithic foragers and Neolithic farmers across a long-lasting boundary between the two. Linearbandkeramik (LBK) farmers reached northern Germany and the Netherlands at around 5500 cal. BC. The farming spread then virtually ceased, while the LBK evolved into the Rössen. North of the farmers were foragers, termed Swifterbant in the Low Countries, and Ertebølle in the Baltic regions (Figure 15.1). Farming only spread north into these areas around 4000 cal. BC.

Forager/farmer relations across this boundary have been much discussed. One major topic is the spread of farmers' artefacts north to the foragers – Figure 15.1 plots adzes of LBK and Rössen manufacture. These have often been interpreted as reflecting the foragers' desire for exotic items made by the farmers, which may be given a high symbolic value (*e.g.* Fischer 1982; Klassen 2002; Verhart 2012). Other items also spread to the north, including flint points and pottery (Vanmontfort 2008; Verhart 2000). Fischer (2002, 376) terms this "the prestige of the exotic". Zvelebil (2006, 185) discusses the contacts in terms of core and periphery: the peripheral foragers imported prestigious goods such as axes, ceramics and ornaments from the core farming area. In return they supplied the farmers with hunter-gatherer products such as furs, honey and seal fat, and the foragers probably suffered a net loss of population as their women married farmers. Others have argued along broadly similar lines (*e.g.* Alexander 1978; Klassen 2002; Verhart 2000). Some have been more cautious (*e.g.* Dennell 1985; Raemaekers *et al*. 2011, 24), but these are in the minority. Only recently have some begun to question the core-periphery scenario (Bogucki 2008; Gronenborn 2009, 2010).

The prestigious foreign artefacts have been ascribed an important role in destabilising forager societies and hastening the introduction of agriculture. Zvelebil (2006) argues that the trade led to increased social competition among foragers, because status was gained by the ownership of such items. As the flow of goods from the farmers increased, so the destabilisation increased: employed in competitive feasting, exotic goods led to an increasingly hierarchical society; further destabilisation might come from the over-exploitation of (for example) fur-bearing animals to pay for the exotic items (Zvelebil 2006). Prestige could also be obtained through the import of exotic foodstuffs such as cereals and domestic animals (*e.g.* Fischer 2002, 2003). Thus the farmers' artefacts played a direct role in the neolithisation of the Rhine-Baltic region.

The assumption that farmers' artefacts have a high symbolic value, and may therefore destabilise forager societies, is one that contemporary European archaeologists regard as self-evidently true, conditioned as we are by our innate certainty that foragers will regard farmers as a superior form of life. This is, however, derived almost entirely from recent European experiences of contact with foragers, and indeed the selective employment even of these. Some of our archaeological interpretations are derived more from anthropological and ethnohistorical contact situations perceived (consciously or unconsciously) to be relevant, than they are from the archaeological record itself.

The best-documented contact situations inevitably derive from the recent past, and it is doubtful whether they are remotely relevant for our understanding of Mesolithic/Neolithic interactions in the Rhine-Baltic area. I will a) examine some anthropologically documented situations from which our understandings are derived; and then b), consider whether the archaeological record of the Rhine-Baltic foragers can be understood in the same terms. I will argue that there are various reasons why the Rhine-Baltic situation is different

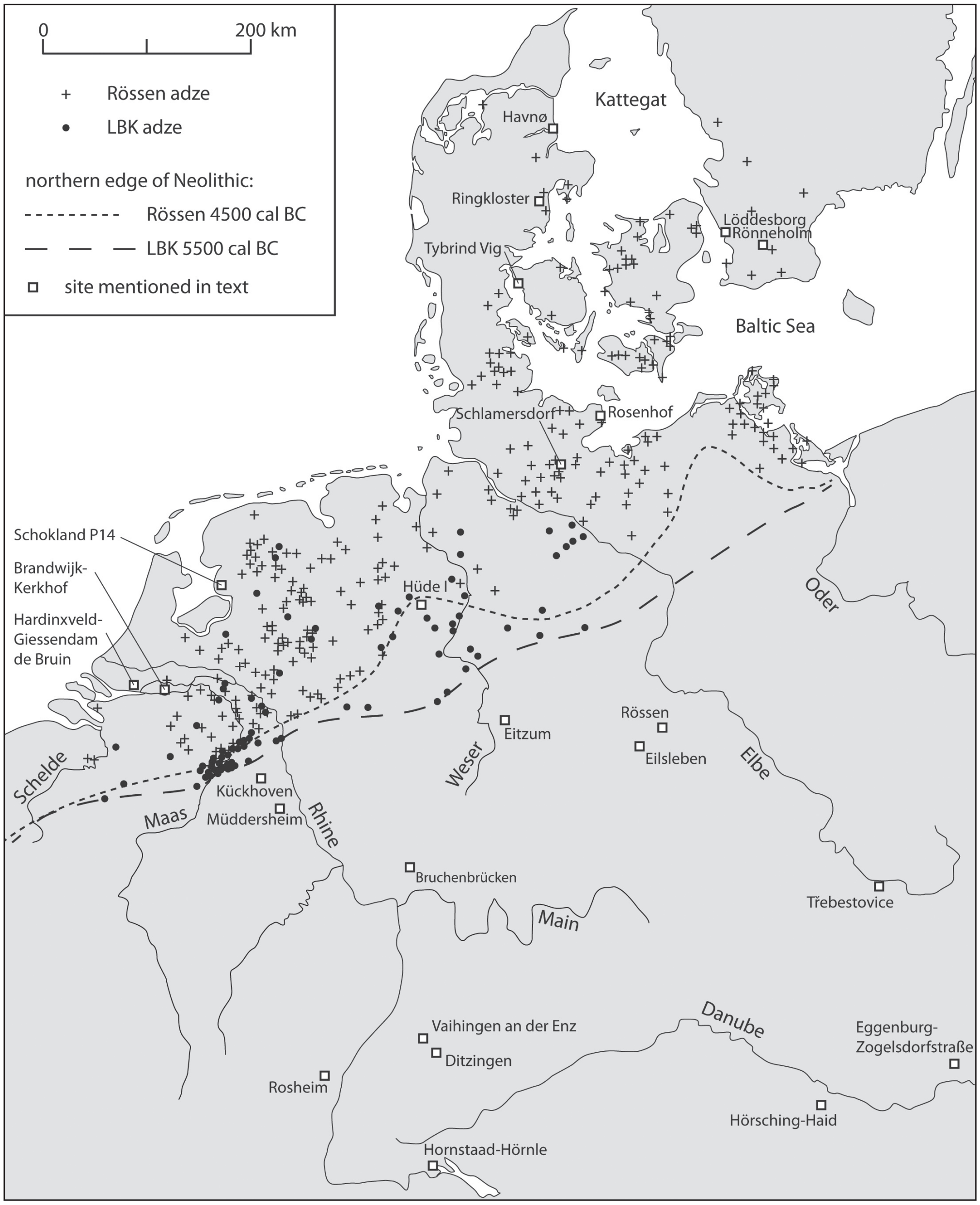

Figure 15.1. Map of the region considered here, showing the approximate northern edge of farming cultures and the distribution of adzes made by farmers found in the area occupied by foragers. Distributions SW of the Elbe from Verhart (2012, figures 3 and 5), NE of the Elbe from Klassen (2002, figure 20.1). Klassen plots only Rössen adzes so any LBK adzes NE of the Elbe are not included.

from the examples we know from anthropology. It is time that archaeology ventured out from under the anthropological comfort zone.

Asymmetrical technology: Europe and the savages

Contact between colonial Europeans and hunter-gatherers has not been characterised by mutual understanding and regard. When even so enlightened a scientist as Charles Darwin encountered Tierra del Fuegians in their native habitat, his culture shock was profound: "I could not have believed how wide is the difference between savage and civilized man.... These poor wretches were stunted in their growth, their hideous faces bedaubed with white paint, their skins filthy and greasy, their hair entangled, their voices discordant, and their gestures violent. Viewing such men, one can hardly make oneself believe that they are fellow-creatures, and inhabitants of the same world"

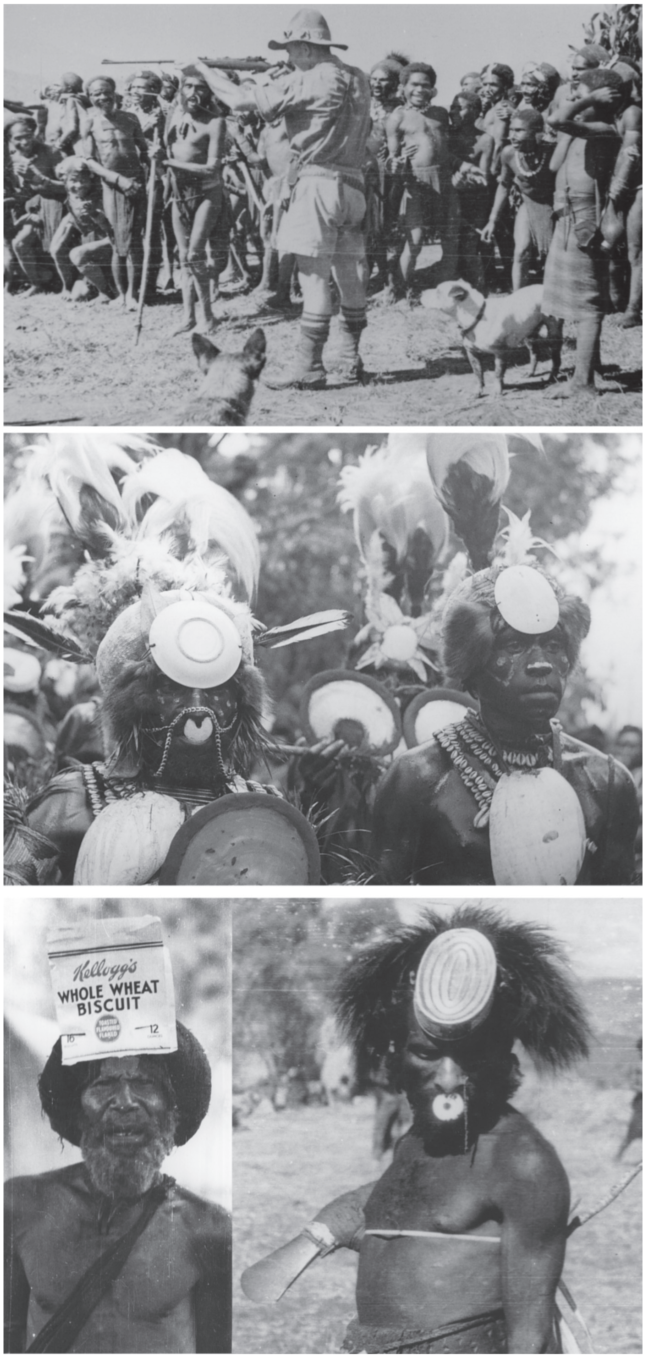

Figure 15.2. Mick Leahy's technology in Highland New Guinea, 1930–35. Top: a rifle causes amazement; centre: a saucer attached to a man's forehead is the symbolic equivalent of an imported marine shell; bottom: other Australian items performing the same role. (I am most grateful to Leo Verhart for providing these photographs).

(Darwin 1860 [1962, 205, 213]). Given scarlet cloth, the Fuegians tied it round their necks; they begged for metal knives and stole them when they could, but were frightened of firearms (*ibid*., 206–7).

Darwin's experience typifies that of many Europeans. This section will examine some European encounters and attempt to distil some common threads. The encounters are varied in time and space, and consider one key aspect: the superior technology of the Europeans. This technological asymmetry characterised relationships not just with foragers, but also with farmers with no knowledge of metals. In the following, two farmer and two forager situations are examined.

Mick Leahy in New Guinea, 1930–35

Michael Leahy was an Australian gold prospector who travelled in Highland New Guinea, where he encountered Papuans who had not previously seen white men. His written account of his travels was published posthumously (Leahy 1991), and has been discussed in an archaeological context by Verhart (2000).

Papuans had no understanding of firearms, and Leahy and his party would shoot birds "to the astonishment of any local natives" (Leahy 1991, 11). Figure 15.2 (top) shows the amazed reactions of one group to his demonstration. In various hostile encounters, Leahy and his party shot and killed a number of Papuans. Papuans imitated firearms by carrying sticks of the right length over their shoulders (*ibid*., 20). Leahy had brought Australian tools to trade, and "the natives were fascinated by steel axes which could cut a tree almost straight through, knives which cut off a stick with one clean blow" (*ibid*., 20). Leahy mentions various instances when Papuans traded, were given, or stole these implements. Sometimes there was a little initial trepidation, because "some sorcery might have been associated with the knives" (*ibid*., 94), but they were soon actively sought.

Leahy also carried non-utilitarian trade items. In one of his first encounters with a frightened Papuan, Leahy placated the man with a gift of red cloth and beads (Leahy 1991, 13). Other items worked in more unexpected ways. Verhart (2000) lays particular emphasis on the Highlanders' desire for marine shells, and Leahy's response, between them a particularly informative aspect of culture contact. In the Mount Hagen region, gold lip shells from the coast were very valuable. The Highland Papuans had no idea where they came from, but thought they might grow on trees like fruit. They were traded inland, becoming ever more worn and fragmented as they moved into the Highlands (Leahy 1991, 98–9). On subsequent trips Leahy brought plentiful supplies of gold lip shell with him, but on his first visit he did not know that they were valuable. He improvised an alternative:

> Having no gold lip shell at that stage, we tried china saucers and plates as a bright, shiny white substitute. These were snapped up, and we wrote Mrs. Wright, the

> cook at Guinea Airways' mess in Lae, to send us any broken crockery or discarded plates. The shards went like hotcakes, and in a few days reappeared, with holes neatly drilled through them, as breast decorations worn suspended from the neck
>
> (Leahy 1991, 99).

Figure 15.2 (centre) shows two Papuans, one wearing a marine shell on his forehead, the other one of Leahy's plates. When plates ran out, anything would do:

> They bartered for almost any article of trade – discarded tins, bottles, or even the coloured labels around meat tins; old razor blades or empty cartridge or bullet shells; or a thin strip of coloured cloth. The natives considered anything associated with our party to be impregnated with spirits and magic that apparently protected us as we traveled among their neighbours and hereditary enemies
>
> (Leahy 1991, 45–46).

The lower two photos in Figure 15.2 show Papuans using such items in place of shells.

But the influx of goods could cause inflation. Small cowrie shells called tambu were a useful form of currency, scarce in the Highlands but easily obtainable on the coast. Many subsequent travellers in the Highlands brought quantities with them, and Leahy noted that "today the shell currency market has become saturated, and the natives want hard cash or folding money" (1991, 94).

This case study exemplifies the situation when technologies are asymmetrical. The 'shock and awe' created by the firearms, the greater efficacy of steel axes and knives, and the exotic nature of the technology in general, endowed all things Australian with a high symbolic value. It was, however, not always like this, as the next example reveals.

European traders in Labrador, 1600–1900

This case study is rather different from Highland New Guinea. The Inuit whom British and French traders encountered on the Labrador coast were hunter-gatherers and thus of potentially great relevance to this discussion. Here too, European goods were highly sought after, but mainly for utilitarian rather than symbolic purposes. The Inuit social response was however similar to what has been argued for the Ertebølle.

Documented contacts between Europeans and Inuit in the seventeenth century were rather limited, but the archaeological record suggests that the Inuit were already heavily dependent on European iron at this time. Much superior to slate and ivory, iron was cold-hammered into traditional Eskimo forms such as harpoons, ulus (semicircular knives), tanged arrowheads and scrapers. Exotic items like beads and clay pipes were extremely rare (Jordan 1976).

In the eighteenth century, French fishermen occupied the southern extremity of Labrador, and contacts increased. Inuit trading and thievery increased markedly. Iron remained the major commodity, but other items were also involved. Significantly, the Inuit made considerable social adaptations: large multi-family houses developed around high-status males. These larger social units provided crews to man the whaling boats that acquired baleen and whale oil for sale to the Europeans. In southern Labrador, close to the French settlements, the Inuit household heads in turn dominated the trade in European goods, acting as middlemen between the French and the more northerly Inuit (Kaplan 1985). One excavated Inuit house contained "five French clasp knives, over eight thousand trade beads, hundreds of spikes and nails, musket balls, gunflints, gun parts, kaolin pipe fragments, spoons, buttons, glass, and ceramic sherds" (Kaplan 1985, 59), amassed for trade to the north. This Inuit social development of 'big men' was entirely due to trade with the Europeans; zooarchaeological studies indicate that the later eighteenth century was a time of relatively benign climate, so ecological factors were not involved (Woollett 1999).

The 'big man' system declined in the late eighteenth century, when the British took over Labrador and wished to discourage trading/raiding forays by the central and northern Inuit. They did this by permitting Moravian missionaries to open mission stations at various points along the northern coast. These missions contained trading posts from which Inuit could obtain European goods and weapons, thus eliminating the need for them to sail southwards (Kaplan 1985).

The sources quoted here make little mention of symbolic importance being attached to European goods by the Inuit. Items like trade beads no doubt had some such importance, but by far the most important commodities were utilitarian items such as iron, and containers. These could be incorporated into Inuit culture without being regarded as symbolically important exotic items. Inuit made considerable use of meteoric iron before European contact (McGhee 1984, 15), so European iron was just 'more of the same'. From the 1840s, stamped earthenware made in Britain was traded to the Inuit. Flat plates suitable for individual European meals were most commonly manufactured; the Inuit, however, preferred bowls, which they used for communal meals in the way they had formerly used wooden or soapstone bowls (Cabak and Loring 2000) (Figure 15.3 top). When broken, the earthenware bowls were mended in the native manner, exactly as if they were made of traditional materials (Stephen Loring pers. comm.) (Figure 15.3 bottom).

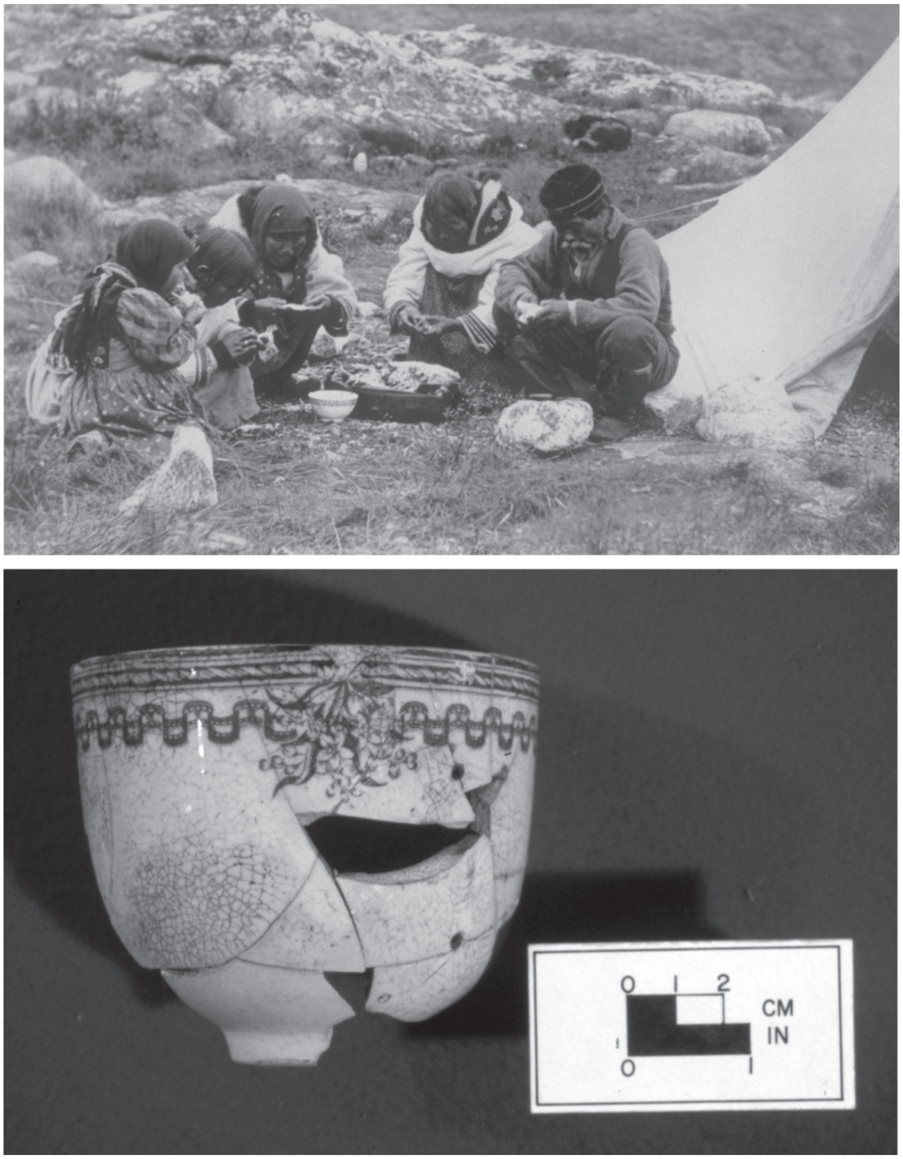

Figure 15.3. Top: a stamped earthenware bowl in use by a Labrador Inuit family at Nain-Okak, about 1912 (from Cabak and Loring 2000, figure 6; reproduced by kind permission of the Moravian Church Archive and Library, London); bottom: stamped earthenware bowl from the Inuit midden at Nain, Labrador, drilled and repaired in the manner traditionally used for soapstone vessels (photograph kindly supplied by Stephen Loring).

English colonists in Jamestown, Virginia, 1607–17

English colonists encountered agricultural Indians around Chesapeake Bay. Although this was over three centuries before Mick Leahy ventured into Highland New Guinea, contacts with the local Indians were in many ways remarkably similar.

The documentary evidence for the first decade of the Jamestown colony has been collected by Haile (1998). The first mention of an English visit to Chesapeake Bay is in fact a Spanish record from 1560, recording the testimony of an English prisoner named only as John, from Bristol. On a French ship some years earlier, he met many Indians. He stated that "…they gave them as many as a thousand marten skins in exchange for knives, fishhooks, and shirts" (Haile 1998, 5). These exchanges were evidently heavily biased in the Europeans' favour. At Jamestown itself, consideration can be divided into three: weapons, tools, and non-functional objects.

Regarding weapons, the colonists' instructions were that these were banned as trade goods; the Indians should not even be taught skills like blacksmithing that might allow them to manufacture their own (Haile 1998, 24). Once again, firearms caused amazement. On 25 May 1607, Gabriel Archer encountered a chief, who:

> …was desirous to have a musket shot off… Our captain caused a gentleman to discharge his piece soldier-like before him, at which noise he started, stop'd his ears, and express'd much fear, so likewise all about him. Some of his people being in our boat leapt overboard at the wonder thereof
>
> (Haile 1998, 111).

When an Indian was caught trying to steal two swords, Captain John Smith had him placed in irons (Haile 1998, 174). Later in 1607 the colonists began to run out of supplies, and the Indians offered food in return for swords and muskets. Smith refused, offering instead beads and axes (*ibid*., 232). The Indians did however obtain some weapons, both from disaffected German labourers and from sailors on visiting ships. The colonists sought to get these back: in 1609 an Indian was held hostage until a stolen pistol was returned (*ibid*., 317–18), and a truce in 1614 specified the return of weapons (*ibid*., 845).

Tools and non-functional objects were however traded freely. In 1612, William Strachey wrote that:

> They are much desirous of our commodities…, and demand after copper, white beads, hoes to pare their cornfields, and hatchets, for which they will give us of such things as they have in exchange, as deerskins, furs of the wildcat, black fox, beaver, otter, arrachoune [raccoon], *etc*., fowl, fish, deer, or bear skins, tried deer's suet made up handsomely in cakes, their country corn, peas, beans, and suchlike
>
> (Haile 1998, 673).

Strachey saw the effects of inflation: in 1610 "…the Virginians were glutted with our trifles and enhanced the prices of their corn and victual, that copper, which before would have provided a bushel [*c.* 35 litres], would not now obtain so much as a pottle [1.9 litres]" (Haile 1998, 441).

Much of the trouble between colonists and Indians was caused by the attempted theft of tools. Knives and axes were apparently valued simply as tools, but in late 1607 the chief Powhatan fell for John Smith's sales talk about beads:

> [Powhatan] fixed his humor upon a few blue beads. A long time he importunately desired them, but Smith seemed so much the more to affect them as being composed of a most rare substance of the color of the skies, and not to be worn but by the greatest kings in the world. This made him half mad to be the owner of such strange jewels, so that, ere we departed, for a pound or two of blue beads he brought over my king for 2 or 300 bushels of corn…
>
> (Haile 1998, 246).

Thus here too firearms created 'shock and awe'. The Indians seem to have attached more symbolic value to non-utilitarian objects such as beads and coloured cloth than they did to steel axes and knives. The final example takes these principles back a further 600 years.

Thorfinn Karlsefni in Vinland, c. *AD 1000*

Eirik's Saga and the Grœnlendinga Saga may provide the earliest detailed description of a European encounter with indigenous foragers. Vinland is probably to be identified with L'Anse aux Meadows, the Norse site on northern Newfoundland (Fitzhugh 1985; McGhee 1984). When Thorfinn Karlsefni met his first Skrælings (the Vikings' term for the natives), his culture shock was in some ways like Charles Darwin's (quoted above): "they were small and evil-looking, and their hair was coarse; they had large eyes and broad cheekbones" (Magnusson and Pálsson 1965, 98).

Many of the elements characterising the later European contacts discussed above were already present in the Norse encounter. Relations were a mixture of hostility and trade. Both sagas record that the Skrælings brought furs to trade, "preferably in exchange for weapons; but Karlsefni forbade his men to sell arms" (Magnusson and Pálsson 1965, 65); and one of Karlsefni's men killed a Skræling whom he caught trying to steal weapons (*ibid*., 66). The Skrælings were impressed with iron axes; following a skirmish in which they got the better of the Vikings:

> …the Skrælings found the other dead Norseman, with his axe lying beside him. One of them picked it up and chopped at a tree with it, and then each one of them in turn tried it; they all thought it a wonderful find, because of its sharpness
>
> (Magnusson and Pálsson 1965, 100, n3).

And as ever, red cloth was sought after:

> What the natives wanted most was to buy red cloth; they also wanted to buy swords and spears, but Karlsefni and Snorri forbade that. In exchange for the cloth they traded grey pelts. The natives took a span [nine inches] of cloth for each pelt, and tied the cloth round their heads. The trading went on like this for a while until the cloth began to run short; then Karlsefni and his men cut it up into pieces which were no more than a finger's breadth wide; but the Skrælings paid just as much or even more for it
>
> (Magnusson and Pálsson 1965, 99).

There is no mention that beads were traded; perhaps the Vikings, not expecting to encounter natives, had not brought any. Later Viking contact with areas further north in Canada does appear to have involved decorative items, because fragments of copper are found on Inuit sites (McGhee 1984; Schledermann 1980).

Asymmetrical technology: conclusions

This brief consideration of a millennium of European contact with foragers and low-technology farmers is instructive at a number of levels. The first conclusion is that the desirability of the colonists' items is not a straightforward issue. Items, such as steel axes and knives, were prized mainly for their utilitarian value – only the Papuans are recorded as giving them any kind of symbolic value, and that would presumably have faded rapidly as they acquired them in quantity, 'domesticated' them, and put them to use. Their great efficacy as working tools was what made these items desirable (and cf. the bowls in Figure 15.3). Steel supplanted stone everywhere – the explorer Mitchell, travelling in the Queensland interior in 1846, found that "even here, on a river utterly unheard of by white men, an iron tomahawk glittered on high in the hands of a chief" (cited in Reynolds 1981, 8). While ownership of a steel axe no doubt conferred a certain cachet, in the examples discussed above this appears to have accrued because of the axes' utilitarian rather than symbolic value.

The 'red cloth and trade bead' category of goods seems to have been accorded more symbolic value, from Thorfinn Karlsefni's ripping off the Skrælings with ever-smaller pieces of cloth, to John Smith's hoodwinking of Powhatan about the blue beads, to Mick Leahy's purveying of broken crockery to the Papuans. Figure 15.2 shows some classic examples of this principle in action. While it would be dangerous to draw too sharp a distinction between the utilitarian axes and the decorative cloth and beads, non-metal using native peoples do appear to have responded somewhat differently to the two categories. Both William Strachey in Virginia and Mick Leahy in Highland New Guinea saw the inflationary dangers in over-supplying such commodities: their value fell to little or nothing.

European weaponry was, of course, what underpinned technological superiority. Thorfinn Karlsefni and John Smith both did their utmost to prevent the natives getting their hands on any, and there was no question that Mick Leahy would have parted with his guns. The French, however, supplied muskets to the Labrador Inuit, even though the Inuit sometimes attacked and killed Frenchmen. It is possible that this was part of a wider geopolitical powerplay. After the French lost control of Labrador to the British in the later eighteenth century, they armed the Montagnais in the interior to enable them to attack the Labrador Inuit, newly part of the British Empire (Jordan 1976). The European powers often armed their own client native peoples to enhance their fur-procuring abilities – and to make life difficult for their enemies (Wolf 1982).

The fundamental question about these anthropological case studies is: to what extent can they be extrapolated to Mesolithic/Neolithic Europe? In the next section I consider the relations between LBK/Rössen farmers, and Swifterbant/Ertebølle foragers.

Symmetrical technology: what did the farmers have that the foragers wanted?

There are two huge differences between the colonial case studies considered above, and the Mesolithic and Neolithic in the Rhine-Baltic area. The first of these is timespan. The prehistoric 1500–year farming standstill (Figure 15.1) is far longer than any of the ethnohistorical situations. This limits the usefulness of the recent examples – recent foragers have been swept aside far more quickly.

Of the four case studies considered above, only the Labrador Inuit underwent a change towards social complexity of the kind often claimed for the Rhine-Baltic foragers. It may fairly be objected that, left to play out over a longer period, the others might have seen parallel developments. The Labrador Inuit case was, however, only possible for geographical reasons: the French traders were located at one end of the forager distribution along the coast. This allowed the Inuit closest to the French to dominate the trade to the north, thus acquiring high status. In contrast the Rhine-Baltic foragers were spread along the northern margin of the farmers; it is hard to see how any individuals could have dominated the trade. Terberger *et al*. (2009, 262) argue that the artefactual distributions suggest that there were no specialised traders; rather the objects moved from hand to hand.

The other huge difference is technology: the farmers did not have firearms, swords, steel axes, trade beads, or red cloth. In the following I will examine the three categories that emerged above: weapons, tools, and non-utilitarian items; and then consider elements of the agricultural economy. I will pose the question: what did the farmers have that the foragers wanted?

Weapons

In the absence of firearms or swords in Mesolithic/Neolithic Europe, consideration is directed towards stone tools. The distinction between a tool and a weapon is problematic – stone axes are normally regarded as tools, but in the LBK death pit at Talheim they were certainly used to kill people. A total of twenty-two cranial injuries were inflicted with flat axes, only four with shoe-last adzes of the kind plotted in Figure 15.1 (Wahl and Trautmann 2012, 85). The adzes are therefore considered as tools, in the next section. The only definite weapons to cross the forager-farmer boundary actually go the 'wrong' way: Mesolithic arrow armatures are found on LBK sites.

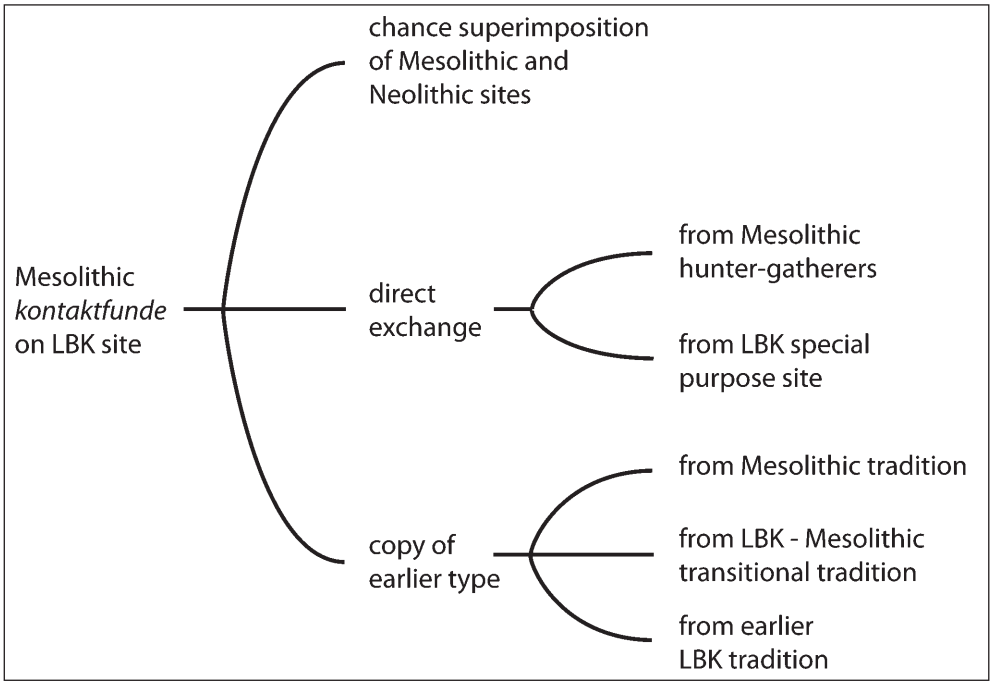
chance superimposition of Mesolithic and Neolithic sites
Mesolithic *kontaktfunde* on LBK site
direct exchange
from Mesolithic hunter-gatherers
from LBK special purpose site
copy of earlier type
from Mesolithic tradition
from LBK - Mesolithic transitional tradition
from earlier LBK tradition

Figure 15.4. Alternative reasons for the presence of Mesolithic microliths on LBK sites. Modified and translated from Lüning (1991, figure 13).

Microliths on LBK sites have been much discussed. The majority are of local Mesolithic type. Some have argued that this indicates continuity from Mesolithic to Neolithic (see Robinson *et al*. 2010 for a discussion). Others argue that they indicate forager-farmer contact, although the chronology and nature of the terminal Mesolithic is largely unknown. What is important here is the way such *kontaktfunde* are discussed. Perhaps the most thorough consideration is presented by Lüning (1991), who sums up his discussion in diagrammatic form (Figure 15.4). *Kontaktfunde* might be due to chance (the top branch). If not, they must derive either from forager/farmer exchange (middle), or they must be copies of earlier types, whether made by foragers or farmers (bottom). Most discussions assume that the arrows arrived with forager clients visiting the farmers to trade; one microlith of definite Scandinavian type comes from the earliest LBK contexts at Bruchenbrücken (Figure 15.1), a definite Mesolithic import (Gronenborn 2010, 562). Consideration is however rarely given to the possibility that the farmers might have regarded Mesolithic arrows as symbolically important. Yet this seems entirely plausible: the northern LBK did remarkably little hunting (Rowley-Conwy 2013, table 1), so their archery equipment was probably not very good. Reconstructions of foragers' bows and arrows however reveal that these were remarkably powerful (Fischer 1989) – as they had to be, when livelihood depended on the efficient killing of wild boar, aurochs and deer. Fragments of a Mesolithic-type bow of elm wood from the LBK site of Kückhoven (Weiner 1995) indicate contact with the hunter-gatherers to the north (Gronenborn 2010, 563), suggesting that the farmers were keen to acquire such items. If any weaponry was regarded with 'shock and awe', it was surely Mesolithic bows and arrows at Neolithic settlements.

Tools

This section considers ground stone axes and ceramics. These are commonly discussed as the kind of item that farmers could supply to foragers. But in the Rhine-Baltic region the foragers manufactured their own versions of both.

The LBK and Rössen adzes (Figure 15.1) were made of stone found only in farming areas (Fischer 1982; Verhart 2012). Their presence among the foragers provides the strongest claim that the foragers regarded farmers' technology in the same way that the natives regarded European technology in the ethnohistoric cases. Yet there are grounds for questioning this. The Ertebølle produced their own ground stone axes, the 'stump-butted axe' or *trindøkse* (Hermansson and Welinder 1997; Johansen 2000). The stump-butted axe did not have a shafthole, but was in other respects similar. The Swifterbant did not produce native-made

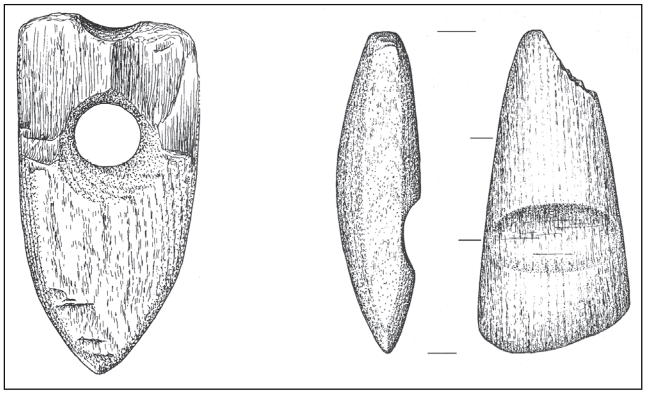

Figure 15.5. Rössen adzes from Denmark, broken during use and reworked. From Fischer (2002, figure 22.7) (Reproduced by kind permission of Anders Fischer).

ground stone axes, but "good functional equivalents" of bone and antler are mentioned by Verhart (2012, 23). If the adzes moved north from hand to hand rather than via entrepreneurs (Terberger *et al*. 2009, 262), a forager obtaining one from a neighbouring foraging camp may have been entirely unaware that the adzes came from a great distance away. Axes also moved south: Ertebølle-type flake axes have been found in LBK contexts at Eitzum, Eilsleben and Müddersheim (Gronenborn 2010, 562) (see Figure 15.1).

How 'special' would European iron and steel axes have been to foragers if those foragers had been producing their own equivalents? Archaeologists regard the LBK and Rössen adzes as very special, because we can identify them and trace their origins. But there is no indication from the archaeological record that Mesolithic foragers thought they were special. Most examples are single finds with no archaeological context, 'special' or otherwise (Raemaekers *et al*. 2011, 16–17). Two points must be stressed. First, there are apparently no copies of LBK or Rössen adzes made by the foragers using local stone. They were evidently not special enough to be imitated. Second, they were not just symbolic, they were used: many were broken during use and reworked for further use. Figure 15.5 shows two such examples from Denmark. The left example broke through the original shafthole (at the top of the surviving fragment), and a new shafthole was drilled. The right example has the old shafthole running across one face. There are similar examples from the Swifterbant (Raemaekers *et al*. 2011, 17–19; Verhart 2012, figures 2 and 11). It is of course possible that the axes were traded in this state (Verhart 2012, 24), but there is no evidence that this was the case.

The issue of inflation is important, particularly given the long time span involved. In two of the ethnohistoric cases, Virginia and New Guinea, inflation resulted from the increased availability of European and Australian goods. This would seem to be a likely outcome in every such circumstance. But Zvelebil (1996, 1998) has argued that the increased import of goods from the farmers would be paralleled by increased competition and destabilisation of forager society. It is, however, hard to see how this could be the case, since the increased availability of imported exotica would decrease their value.

Ceramics, too, were produced indigenously by the foragers, both Swifterbant and Ertebølle. The earliest Swifterbant ceramics date from *c*. 5000 cal. BC (Raemaekers and de Roever 2010). The earliest Ertebølle ceramics come from Schlamersdorf in Holstein (see Figure 15.1), which has produced dates around 5300–5100 cal. BC (Hartz *et al*. 2000, Table 3). Doubts have been raised about this date (Crombé 2009, 483), and most are not older than 4700 cal. BC (Andersen 2007; Hartz *et al*. 2007). Both Swifterbant and Ertebølle are thus later than the early LBK – but the foragers did not copy the farmers' vessels: "there are no signs of any contact between southern Scandinavian Mesolithic groups and Central European Neolithic societies that reflect any interest among the foragers in the farmers' pottery" (Müller 2011, 291). They copied those made by foragers further up the Baltic. This has become apparent as the various eastern Baltic ceramic traditions have been defined and dated. Figure 15.6 shows the main groupings (Hallgren 2008; see also Hallgren 2004, 2009). All these are dated to before 5000 cal. BC (Hallgren 2004, Figure 15.7), and the pointed base Ertebølle vessels clearly derive from them. A pointed base vessel of Ertebølle origin has been found on the LBK site of Rosheim (Gronenborn 2009, 536), a long way up the Rhine (Figure 15.1).

Since the foragers were not referencing the farmers in the axes or ceramics they made themselves, it is hard to depict them as clients desiring everything the farmers manufactured. Once again the ethnohistoric analogy fails to explain the archaeological record.

Non-utilitarian items

The 'red cloth and trade bead' category was accorded most symbolic importance in the ethnohistoric contact situations discussed above. There was little visible activity in this area in the Rhine-Baltic Mesolithic, however, and what there is does not suggest the export of farming commodities to the foragers. The LBK cultivated flax and reared sheep, but this was long before the emergence of linen cloth or woolly sheep, so it is unlikely that textiles were a major farming export. A piece of worked amber was found at the LBK site of Kückhoven, probably acquired from the foragers (Terberger *et al*. 2009, 266). Another category is more

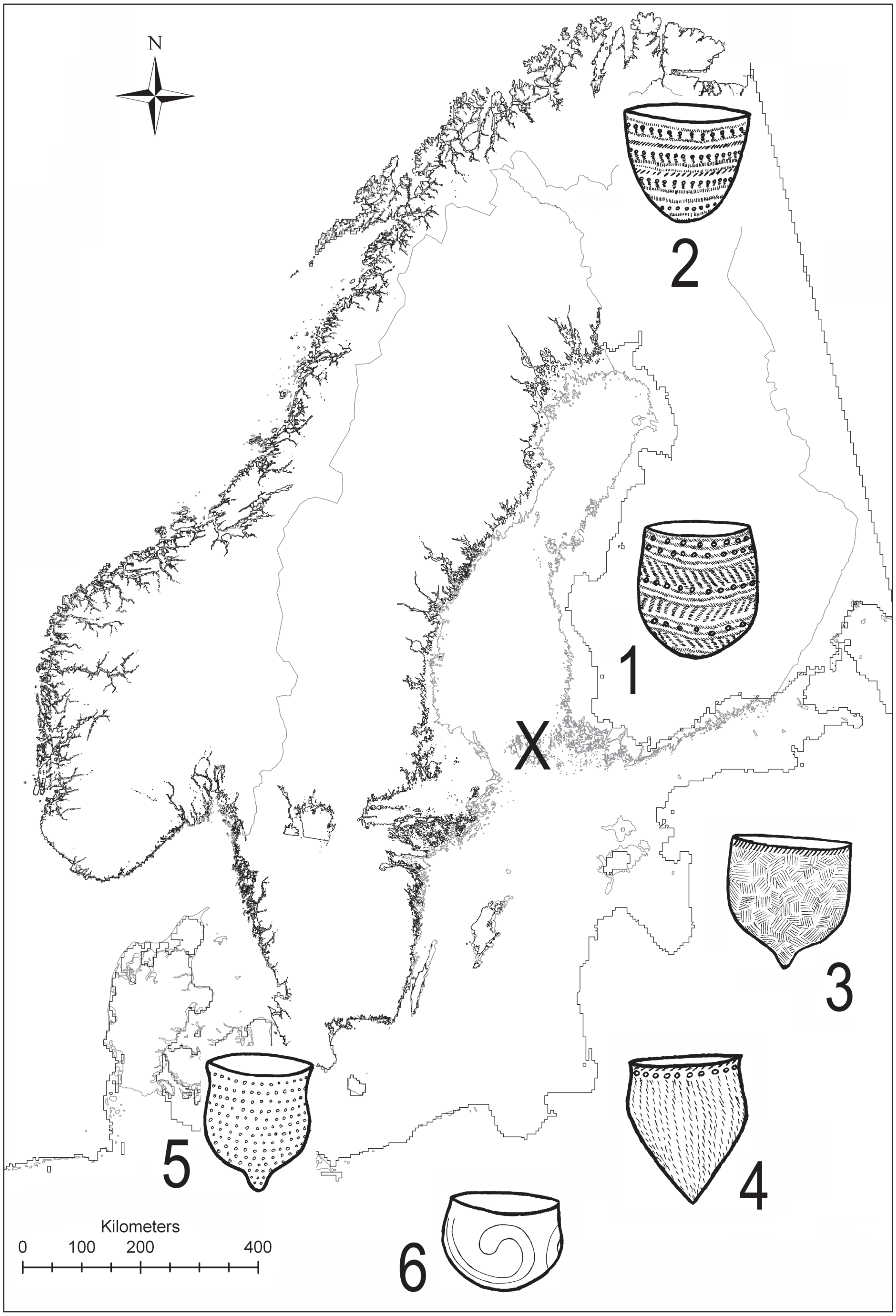

Figure 15.6. Ceramic traditions in the Baltic: 1. early older Comb Ware; 2. Säräisniemi; 3. Narva; 4. Neman; 5. Ertebølle; 6. LBK Neolithic. After Hallgren (2008, figure 4.1) (I am grateful to Fredrik Hallgren for permission to reproduce this figure, and for supplying a high-resolution original).

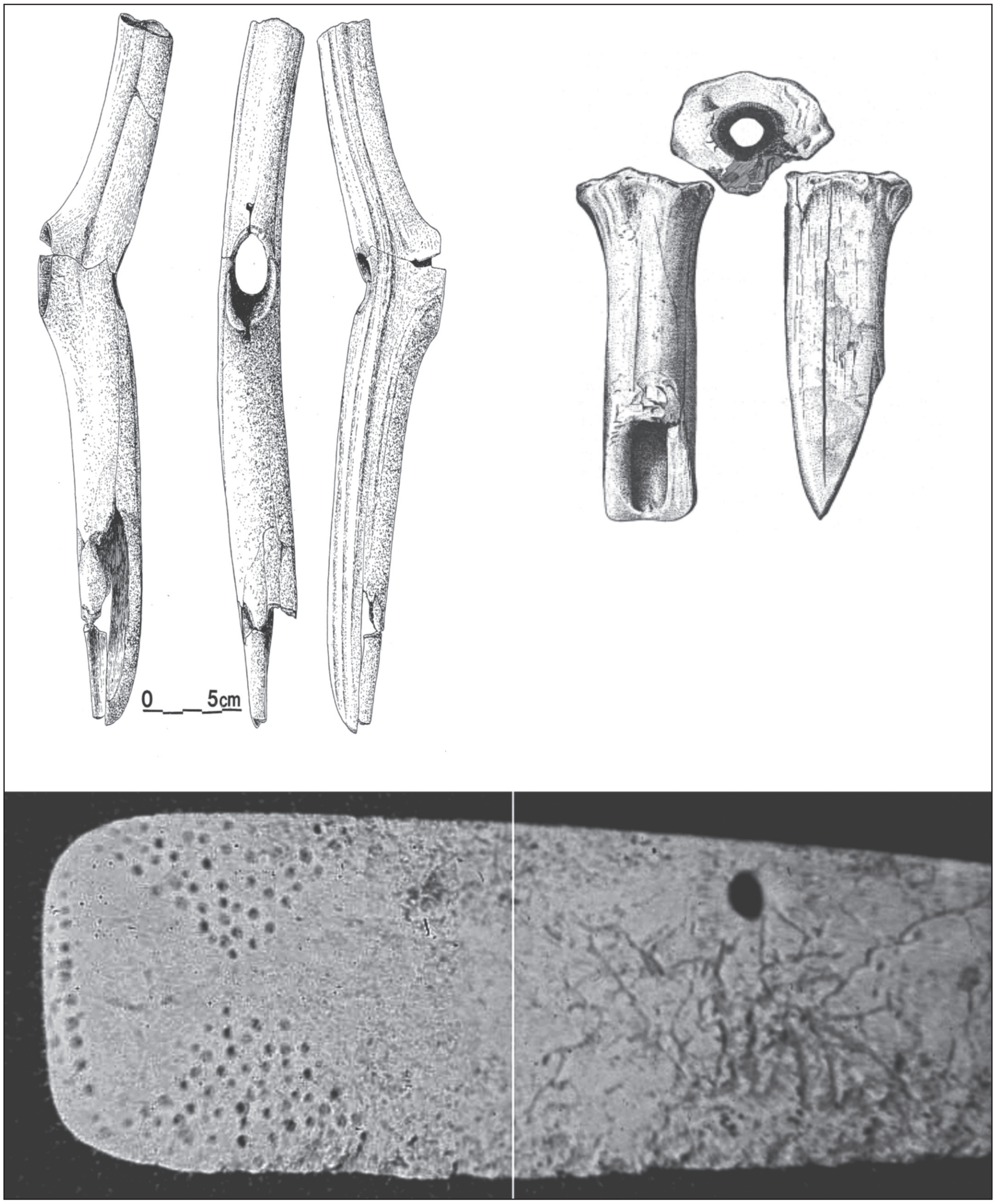

Figure 15.7. Bone objects adopted by farmers from forager originals. Top left: T-axe from Brzesc Kujawski; top right: Mesolithic bone chisel from Hohen Viecheln; bottom: decorated bone from Oslonki. After Bogucki (2008, figures 5.3, 5.6 and 5.8) (I am grateful to Peter Bogucki for permission to reproduce these figures, and for supplying high-resolution originals).

widespread: shell pendants and buttons (German *doppelknöpfe*). Pendants made of oyster shell have been found at Hornstaad-Hörnle on the Bodensee in southern Germany (Figure 15.1) (Heumüller 2009, 2012). Oysters are widespread round the coasts of Europe, and could have been obtained from anywhere – even early farming communities in the Mediterranean. The distinctive buttons, mostly circular with a groove cut round the edge, are found not just at Hornstaad-Hörnle, but also at Rössen and Třebestovice near the Elbe, and Hörsching-Haid and Eggenburg-Zogelsdorfstraße on the upper Danube (Heumüller 2009, Abb. 124; 2012, Abb. 5). The species of shell from which they are made has not yet been identified, and freshwater mussel (*Unio* sp.) cannot be ruled out. But if they are made of marine shell, they may come from the Ertebølle area because identical ones have been found at Havnø in Denmark (Andersen 2008). If this link is established, then the oyster pendants might come from the Ertebølle as well. This chain of inference may be disproved in the future; but if the buttons really come from the Ertebølle then they were apparently regarded as 'special', because copies are known in a variety of other materials including stone, boar tusk, bone and pottery – all white materials, imitating the natural colour of the shell specimens (Heumüller 2009, 2012).

T-shaped antler axes are found on both forager and farmer sites. The T-axe is usually viewed as a Neolithic tool traded to (or copied by) the foragers (*e.g.* Klassen 2002, 314–15; Price and Gebauer 1992, 101; Solberg 1989, 266). However, dating evidence suggests that they originated among the foragers, and were traded to the farmers (Crombé *et al* 2002; Bogucki 2008; Gronenborn 2009). The T-axe is discussed in this section because some farmers seem to have accorded it a symbolic significance – although the foragers did not. Peter Bogucki argues that the T-axe (Figure 15.7) is a distinctly northern form. They are widespread throughout the Ertebølle and Swifterbant, where they are apparently purely functional. At the LBK site of Brześć Kujawski in Poland, they are however found in male graves, and so were evidently accorded a symbolic significance in farming society. They were manufactured at Brześć Kujawski, not imported as finished artefacts, but since they have no antecedents in the central European Neolithic, the concept evidently derived from the foragers (Bogucki 2008, 55–56).

Bone objects with geometric decoration likewise have a background in the Ertebølle, but not in the Neolithic. A decorated piece from the LBK site of Osłonki in Poland is shown in Figure 15.7, and the unique bone armlets in female graves at Brześć Kujawski, similarly decorated, suggest that the farmers regarded decorated bone objects as symbolically important (Bogucki 2008, 56–58). Further west, antler objects with Mesolithic-type decoration have been found on LBK sites as far south as Vaihingen an der Enz and Ditzingen (Gronenborn 2010, 563). Finally, bone chisels have a deep history in the Mesolithic but not in the Neolithic; these too turn up at Osłonki (Bogucki 2008, 59). Bogucki's intriguing hypothesis is thus that objects of symbolic importance were flowing more from foragers to farmers than vice versa. He adds that, since Ertebølle watercraft are far more impressive than those of the farmers, it is likely that Ertebølle people were the main traders, voyaging from the coasts up the rivers into the farming areas.

Domestic animals

It is sometimes assumed that foragers would aspire to own domestic animals in the same way that they would aspire to own a Neolithic adze: simply as the status-conferring product of a technologically superior society. This view has its roots in progressivist schemes of social evolution; more recently the practicalities have been addressed more directly. Some of the ethnohistorical situations discussed above have involved animals. Domestic animals being taken into forager communities may be considered in two categories: those linked to travel and hunting; and those forming a primary food source.

Recent foragers have adopted domestic animals to help with travel and hunting. The adoption of the horse by the Indians of the Great Plains of North America is perhaps the best-known example. A variety of pedestrian foragers, and also some horticulturalists, became highly mobile bison hunters after domesticating feral horses. Their entire cultures were revolutionised by this (*e.g.* Ewers 1955; Holder 1970). There are also some reports of Australian Aborigines riding horses (Reynolds 1981, 46–47). Both these were in areas of open plains, where there was plenty of fodder for the horses and few barriers to movement. Most foragers had dogs when contacted by Europeans, but the Tasmanians did not even know of their existence. "Yet within a few years of seeing their first dogs, the Tasmanians had recognised the potentiality of the animal, formed close bonds with it, and had incorporated it fully within their culture" (Jones 1970, 259).

This rapid adoption of technologically useful animals contrasts markedly with foragers' attitude towards food animals. Mobile foragers would find it very difficult to incorporate a small number of domestic animals – a couple of cattle are simply not a practical add-on to a lifestyle determined by the demands of foraging (Rowley-Conwy 2013, 301). The Skrælings of Vinland, the first Americans ever to see domestic cattle, were so terrified by the bellowing of Thorfinn Karlsefni's bull that they ran away (Magnusson and Pálsson 1965, 65). Australian Aborigines reacted similarly (Reynolds 1981, 9). When domestic cattle and sheep became more common, Aborigines frequently stole them – but not in order to create domestic herds of their own. Aborigines sometimes drove off herds of sheep and feasted on them until they were used up, and then carried out a new raid (Reynolds 1981, 162–163). More often they killed the domestic stock in order to punish the white colonists:

> On the troubled McIntyre frontier the squatter Jacob Lowe lost seventy-five cattle in a single night raid. The local clans had clubbed and speared the herd but none had been taken for food. In fact only two carcases had been cut open. The hearts had been taken out and were placed on two poles stuck in the turf facing one another. The message was unmistakable…. The Aboriginal objective was clearly not food but the desire 'to drive us away out of the district – to frighten us'
>
> (Reynolds 1981, 106).

Even the settled Indian horticulturalists of Virginia had no use for the Europeans' domestic animals, but just killed them. Zooarchaeological study reveals that domestic animals predominated in colonial assemblages virtually from the start (Bowen and Andrews 2000). William Strachey noted in 1610 that "Powhatan… and his people destroyed our hogs to the number of about six hundred" (Haile 1998, 441). In 1611 Sir Thomas Dale started building defensive blockhouses and palisades "to prevent the Indians from killing our cattle" (*ibid*., 523). Colonisation proceeded by impaling ever larger areas to keep the Indians out – by 1614, Rochdale Hundred had "a cross-pale well-nigh four miles long… in which hundred our hogs and other cattle have twenty miles circuit to graze in securely" (*ibid*., 826) – and peace deals specified that the colonists' cattle were to be left alone (*ibid*., 825).

These examples caution us to be wary of claims of domestic livestock among the foragers. Some claims have been advanced. Zvelebil (1998, Figure 1.6) listed no fewer than six possible instances of domestic cattle in the Ertebølle (see Figure 15.1 for locations), but not one stands up to scrutiny. At Dąbki in Poland all the Mesolithic cattle were wild (Kabacinski *et al*. 2009), and at Rosenhof the few claimed domesticates have been demonstrated by microbiological analyses to be wild aurochs (Noe-Nygaard *et al*. 2005; Scheu *et al*. 2008). Stratigraphic contexts are extremely problematic at Löddesborg (Welinder 1998) and Hüde I (Raemaekers 1999, 72–91), and in any case no Mesolithic bones have ever been published from the latter. The faunal reports from neither Tybrind Vig (Enghoff 2009) nor Ringkloster (Rowley-Conwy 1998) make any claims for domestic animals; it is not clear how this misleading impression could have arisen. Except for Hüde I, these sites are hundreds of kilometres north of the farmers, and it would be very difficult to drive domestic animals through dense woodland for these distances – this was not open country of the kind through which Aborigines drove their rustled sheep. Three claims of domestic animals come from the Swifterbant area (Figure 15.1). Those from Schokland P14 (Gehasse 1995) and Brandwijk-Kerkhof (Robeerst 1995) are problematic (Rowley-Conwy 2013). The most likely Mesolithic domestic animals are the goat bones from Hardinxveld-Giessendam De Bruin (Oversteegen *et al*. 2001). They are closest to the LBK, perhaps within trading or rustling distance, but they have not been directly radiocarbon dated.

Domestic cattle cannot simply slide along Mesolithic trade routes and become incorporated into forager culture as if they were stone axes (contra Zvelebil 1998, 17–18; 2006, 185). The rustling and slaughter of domestic stock, or the trading of joints of meat, would no doubt have occurred, but would necessarily be limited to areas very close to the farming frontier. And at the moment, there is remarkably little archaeological evidence even for these activities.

Cultivated cereals

The Swifterbant and Ertebølle foragers would have been well able to cultivate small stands of cereals, at least near semi-permanent or permanent settlements where people were not absent during the growing season. However, charred cereal grains have so far not turned up in Mesolithic contexts. The only evidence in favour of Mesolithic cereal cultivation is the presence of 'cereal-type' pollen in the palynological record. This has come under increasing criticism (Behre 2007; Lahtinen and Rowley-Conwy 2013). Unless and until charred cereal grains are found and are directly dated to the Mesolithic, cultivation remains unsupported.

A small parcel of cereals, a 'fertile gift' (Jennbert 1984), would be relatively easy to transport. Barley might have been attractive as a producer of beer – an 'intoxicating gift' – and various foragers indeed practiced small-scale cultivation of intoxicants: tobacco in North America (Fritz 2006), millet among the Ainu (Watanabe 1972). A desire to get drunk could well have motivated Mesolithic people to acquire barley. However, Mesolithic people had their own means of getting drunk. The site of Rönneholm in Sweden has produced a large mass of raspberry seeds, two centimetres deep and covering about half a square metre; it would have taken about 20 kg of raspberries to produce this many seeds (Sjöström and Dehman 2009, 48–49). It is unlikely that such a heap of fruit would have been piled up and then just allowed to rot away. It is more likely that the seeds were dumped after the berries were soaked to make wine.[1] The foragers were therefore self-sufficient even with regard to alcohol.

So what did the farmers have that the foragers wanted?

The answer is: not very much. Table 15.1 summarises the evidence discussed above. The foragers evidently used adzes for woodworking, but the technological capabilities of foragers and farmers were symmetrical: the foragers produced their own adzes, and there is no reason to suppose they were inferior. The foragers showed little interest in farmers' ceramics, preferring to make their own according to their own stylistic ideas, which were derived from other foragers further up the Baltic. Domestic animals and cultivated plants, such important symbols of development and progress to us modern Europeans, seem likewise to have held little interest.

The foragers, it seems, had items that the farmers wanted. In discussions like this it is obligatory to cast the foragers as the clients by mentioning 'forest products':

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[1] I am grateful to Mr Jake Newport for this suggestion.

Item	Direction	Symbolic value?
Bows	To farmers	'Shock and awe' for farmers
T-axes	To farmers	In farmers' burials
Amber bead	To farmers	In both societies
Oyster pendants	To farmers?	Farmers only make pendants
Shell buttons	To farmers?	Farmers copy in other white materials
Decorated bone	To farmers	In farmers' burials
Stone adzes	To foragers	No – not copied by foragers
Pottery	Both have	No – not copied by foragers

Table 15.1. Details of items crossing the forager–farmer boundary.

furs, and honey. But the presence of microliths and a Mesolithic bow on LBK sites suggests that the farmers actively sought out foragers' hunting gear. The foragers were likely to have been superior in other areas of technology as well, for example canoes, harpoons, fishing nets and so on. If Bogucki's (2008) hypothesis is correct, the farmers also accorded symbolic significance to forager artefacts that had no such significance among the foragers themselves. Bogucki (op. cit., 61) proposes that Ertebølle voyageurs were the main traders, penetrating far up the river networks in their superior watercraft, and Gronenborn (2009, 2010) also argues that the hunter-gatherers were the principal travelling traders. It is noteworthy that the forager imports plotted in Figure 15.1 all come from sites quite close to the Rhine-Main river system, and the Polish sites discussed by Bogucki are close to the Vistula.

Conclusion: beyond the anthropological comfort zone

I have argued that we have placed too much weight on the anthropological and ethnohistorical accounts of farmer-forager contact in our interpretations of Mesolithic/Neolithic contact in northern continental Europe. The contact situations in the last millennium have been between peoples with asymmetrical technologies. This has inevitably led to the foragers becoming clients of the colonial people, supplying 'forest products' in return for superior technology for a brief time, before being swept aside by the global march of cultural evolution.

When the technologies were symmetrical, as they were in the Mesolithic and Neolithic, there is no reason at all to suppose that the foragers were peripheral clients of the farmers. We need to move beyond our anthropologically-derived understanding if we are to comprehend anything of the 1500-year interactions between peoples with similar technologies. The exchange situation may have been more balanced than we usually assume. The foragers may even have had the upper hand: perhaps we should consider recasting the farmers as the clients on the cultural periphery. The foragers had after all developed sophisticated means of exploiting their environment, and maintained a high population density in stable residential centres. And they had been doing this for millennia before the arrival of farming. The farmers on the other hand were carrying an alien economy into an environment to which it was not adapted, and which they initially did not know. They may have needed all the help they could get.

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